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Completion Report for Regional Aquifer Well R-30

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Responsible project manager:

Ted Ball	[signature]	Program Manager	Environmental Programs	8/18/10
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

Bruce Schappell	[signature]	Executive Director	Environmental Programs	8/24/10
Printed Name	Signature	Title	Organization	Date

Responsible DOE representative:

Everett Trollinger	[signature]	Federal Project Director	DOE-LASO	8-24-10
Printed Name	Signature	Title	Organization	Date

EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, development, and aquifer testing of regional groundwater monitoring well R-30, located north of Ancho Canyon, within Los Alamos National Laboratory (the Laboratory) Technical Area 49 (TA-49). Well R-30 was installed to provide a regional aquifer monitoring well downgradient of TA-49, establish water levels in the regional aquifer in this area, and determine whether perched groundwater occurs in the vadose zone downgradient of Material Disposal Area AB.

The R-30 borehole was successfully completed to total depth of 1196.0 ft below ground surface (bgs). It was drilled using dual-rotary fluid-assisted and standard air-rotary drilling methods. Drilling fluid additives included potable water and foaming agent. Injection of foam was discontinued at 1021 ft bgs, roughly 100 ft above the anticipated top of the regional aquifer.

During drilling, the borehole was advanced through the Tshirege Member of the Bandelier Tuff, the Cerro Toledo interval, the Otowi Member of the Bandelier Tuff, the Guaje Pumice Bed, and the Puye Formation, with a thin interbed of Cerros del Rio volcanic rocks within the Puye Formation.

The R-30 monitoring well was completed with a 20.0-ft-long single screen from 1140.0 to 1160.9 ft bgs to evaluate water quality and measure the water level in the regional aquifer within the Puye Formation. The composite depth to water after installation and development was 1124.1 ft bgs.

The well was completed in accordance with the New Mexico Environment Department–approved well design. Hydrogeologic testing indicated the well is productive and will perform effectively to meet planned objectives. A dedicated water-level transducer and sampling system were installed at R-30, and groundwater sampling will be performed as part of the facility-wide groundwater-monitoring program.

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Acronyms and Abbreviations

amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth to water
EES-14	Earth and Environmental Sciences Group
Eh	oxidation-reduction potential
EP	Environmental Programs (Directorate)
EPA	Environmental Protection Agency (U.S.)

gpd	gallons per day
gpm	gallons per minute
HE	high explosives
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
hp	horse power
IC	ion chromatography
I.D.	inside diameter
LANL	Los Alamos National Laboratory
LH3	low-level tritium
MDA	material disposal area
µS/cm	microsiemens per centimeter
mV	millivolt
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
PETN	pentaerythritol tetranitrate
pH	potential of hydrogen
PVC	polyvinyl chloride
Qal	Quaternary alluvium
Qbo	Otowi Member of the Bandelier Tuff
Qbog	Guaje Pumice Bed of Otowi Member of the Bandelier Tuff
Qbt	Tshirege Member of the Bandelier Tuff
Qct	Cerro Toledo interval
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RPF	Records Processing Facility
SC	specific conductance
SOP	standard operating procedure
SU	standard unit
TA	technical area
TATB	triaminotrinitrobenzene
Tb 4	Cerros del Rio volcanic rocks

TD	total depth
TOC	total organic carbon
Tpf	Puye Formation
TU	tritium unit
VOC	volatile organic compound
WCSF	waste characterization strategy form
WES-EDA	Waste and Environmental Services Division–Environmental Data and Analysis
wt%	weight percent

1.0 INTRODUCTION

This completion report summarizes site preparation, borehole drilling, well construction, well development, aquifer testing, and dedicated sampling system installation for regional groundwater monitoring well R-30. The report is written in accordance with the requirements in Section IV.A.3.e.iv of the Compliance Order on Consent (the Consent Order). Well R-30 was drilled, constructed, developed and tested from March 15, 2010 to April 15, 2010, at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Programs (EP) Directorate.

Well R-30 is located north of Ancho Canyon, within Technical Area 49 (TA-49) near its eastern boundary (Figure 1.0-1). The primary purpose of well R-30 is to monitor groundwater in the regional aquifer at the eastern edge of TA-49 and downgradient of Material Disposal Area AB.

Other hydrogeologic and geochemical objectives were to establish the water level in the regional aquifer, determine whether perched-intermediate groundwater is present, and evaluate the presence and composition of volcanic rocks in the subsurface.

The borehole was advanced to a total depth (TD) of 1196.0 ft below ground surface (bgs) and completed with one 20-ft screened interval in the Puye Formation. The screen was installed from 1140.0 to 1160.9 ft bgs. The depth to water (DTW) after well installation and development was 1124.1 ft bgs on April 11, 2010. Cuttings samples for lithologic evaluation were collected over 5-ft intervals in the R-30 borehole from ground surface to TD. Postinstallation activities included well development, aquifer testing, surface completion, and geodetic surveying. Future activities will include site restoration and waste management.

The information presented in this report was compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information, are on file at the Laboratory's Records Processing Facility (RPF). This report contains brief descriptions of activities and supporting figures, tables, and appendices associated with the R-30 well installation project. Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to the New Mexico Environment Department (NMED) in accordance with U.S. Department of Energy policy.

2.0 PRELIMINARY ACTIVITIES

Preliminary activities included preparing administrative planning documents and preparing the drill site and drill pad. All preparatory activities were completed in accordance with Laboratory policies, procedures, and regulatory requirements.

2.1 Administrative Preparation

The following documents helped guide the implementation of the scope of work for well R-30:

- "Drilling Work Plan for Regional Aquifer Well R-30" (LANL 2009, 107422)
- "Well R-30 Drill Plan, Installation of Well R-30, TA-49, Los Alamos National Laboratory, Los Alamos, New Mexico" (North Wind Inc. 2010, 109458)
- "Integrated Work Document for Regional and Intermediate Aquifer Well Drilling" (LANL 2007, 100972)

- "Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan" (LANL 2006, 092600)
- "Waste Characterization Strategy Form for South Canyon Wells R-29 and R-30 (TA-49, MDA-AB) Regional Groundwater Well Installation and Corehole Drilling" (LANL 2009, 107444)

2.2 Site Preparation

Laboratory personnel prepared the drill pad several weeks before mobilization. The drill rig, air compressors, trailers, and support vehicles were initially mobilized to the drill site on March 12 and 13, 2010. Alternative drilling tools and construction materials were staged at the Pajarito laydown yard, near the intersection of Pajarito Road and NM 4.

The office trailer, generators, and general field equipment were moved on-site after mobilization of the drilling equipment. Safety barriers and signs were installed around the cuttings containment pit and along the perimeter of the work area. Potable water was obtained from fire hydrant #13-719 near the entrance of TA-49 at the intersection of New Mexico 4 and Frijoles Mesa Road, approximately 1.2 mi from the drill site.

3.0 DRILLING ACTIVITIES

This section describes the drilling strategy and approach and provides a chronological summary of field activities conducted at monitoring well R-30.

3.1 Drilling Approach

The R-30 borehole was drilled using a Schramm Inc. T130XD Rotadrill dual rotary drilling rig with casing rotator. The dual-rotary system allows for advancing the casing with the casing rotator while drilling with conventional air/mist/foam methods with the drill string. The Schramm T130XD drill rig was equipped with conventional 5.5-in.-outside diameter (O.D.) dual tube drill pipe, tricone bits, downhole hammer bits, and other necessary drilling equipment. Auxiliary equipment included three Ingersoll Rand 1070 ft^3/min trailer-mounted air compressors and two Sullair 1150 XHH skid-mounted air compressors. Three sizes of casing were used: 24-in., 18-in., and 12-in. A53 grade B flush-welded mild carbon-steel casing. The dual-rotary technique used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole. In addition, the casing sizes selected ensured that the required 2-in.-minimum annular thickness of the filter pack around a 5.6-in.-O.D. well, as required by the Consent Order (Section X.C.3), would be met. Cuttings samples were collected at 5-ft intervals in the borehole from 0 to 1196.0 ft bgs to characterize the hydrostratigraphy of rock units encountered in the borehole.

Potable water and Bariod brand AQF-2 foaming agent were used, as needed, between ground surface and 1021 ft bgs (approximately 100 ft above the anticipated top of the regional aquifer). The fluids were used to cool the bit and help lift cuttings from the borehole. Total amounts of drilling fluids introduced into the borehole are presented in Table 3.1-1.

3.2 Chronology of Drilling Activities

On March 15, 2010, dual rotary borehole advancement began at R-30 with 24-in. steel casing and a 23-in. tricone bit. On March 16, the drill string was advanced to a depth of 65.5 ft bgs, with a 24-in. steel conductor casing simultaneously advanced via dual-rotary methods to a depth of 63.0 ft bgs. At that point, the drill string was tripped out and 18-in. steel casing emplaced in the 24-in. conductor casing to a depth of 65.5 ft bgs.

Between March 16 and 18, an open borehole was drilled with the 17.5-in. tricone bit from 65.5 to 1034 ft bgs. Drilling activities were paused, water and foam injection was temporarily discontinued, and the discharge line was monitored for signs of perched water at connections on two separate occasions from 881.0 to 941.0 ft bgs. All returns were dry, and no perched water was encountered. Use of AQF-2 foaming agent was discontinued at 1021.0 ft bgs.

On March 18, downhole tools were tripped out in preparation for the Laboratory's video camera and geophysical tools. The Laboratory conducted open-hole video, gamma, and induction logging on March 18 (see section 6.0 for logging details). The Laboratory's borehole video camera, run to 906 ft bgs, confirmed both the 24-in. and 18-in. casing depths and the absence of perched zones to 905 ft bgs.

Between March 18 and 20, 12-in. casing was installed, and the borehole was advanced to a depth of 999.1 ft bgs. Preparations were made on March 20 to continue drilling with a 14.3-in. hammer bit. On March 21, the borehole and 12-in. casing were advanced from 1034.0 to 1098.0 ft bgs. At 1090 ft bgs, the top of the Cerros del Rio volcanic rocks, drilling activities were paused for 2.25 h, and the borehole was blown dry to monitor for perched water, which was not encountered. Drilling resumed, and the borehole was advanced with the 14.3-in. hammer bit from 1098.0 to 1118.0 ft bgs.

Between March 21 and 23, the borehole was advanced from 1118.0 to 1153.0 ft bgs. Regional groundwater was encountered at 1153.0 ft bgs on March 23. After a recovery period, the DTW was measured at 1125.3 ft bgs, and a screening sample was collected at 1138 ft bgs near the top of the regional aquifer on the morning of March 24.

On March 24, borehole TD was reached at 1196.0 ft bgs, and the 12-in. casing was set at a depth of 1191.4 ft bgs to prepare for well-installation activities. The DTW was monitored throughout the night on March 24 and was tagged consistently at 1124.1 ft bgs. A second regional aquifer sample was collected on the morning of March 25 from 1195 ft bgs, and the borehole was prepared for running the Laboratory's geophysical survey.

On March 25, Laboratory personnel ran a gamma log. On the night of March 25, the casing shoe was cut at 1189.5 ft bgs, leaving 1.9 ft of 12-in. casing in the borehole.

During drilling, 24-h operations consisted of two shifts 12-h/d, 7 d/wk. No problems with borehole instability were encountered.

4.0 SAMPLING ACTIVITIES

The following sections describe the cuttings and groundwater sampling activities conducted during the drilling and completion of monitoring well R-30. All sampling activities were conducted in accordance with the drilling work plan (LANL 2009, 107422).

4.1 Cuttings Sampling

Cuttings samples were collected from the borehole at 5-ft intervals from ground surface to TD of 1196.0 ft bgs. Over each interval, approximately 500 mL of bulk cuttings were collected by the site geologist from the discharge cyclone, placed in resealable plastic bags, labeled, and archived in core boxes. Smaller size fractions (>#10 and >#35 mesh) were sieved from the bulk cuttings and placed in chip trays along with unsieved (whole rock) cuttings. Recovery of drill cuttings was excellent with 97% recovery over the borehole interval. Intervals with no recovery included 15 to 20 ft bgs, 300 to 305 ft bgs, 320 to 330 ft bgs, 360 to 370 ft bgs, 380 to 390 ft bgs, and 440 to 445 ft bgs. Radiation control technicians screened cuttings before they were removed from the site; all screening measurements were within the range of background values. The core boxes and chip trays were surveyed and submitted to the Laboratory's archive at the conclusion of drilling activities. The borehole lithologic log for R-30 is presented in Appendix A and summarized in section 5.1.

4.2 Water Sampling

No perched water zones were detected while drilling R-30.

An initial regional groundwater screening sample was collected by airlifting from the top of the regional aquifer at 1138 ft bgs on March 24, 2010. Another screening sample was collected from 1195 ft bgs near the borehole TD on March 25 by airlifting. Regional groundwater samples were analyzed for metals, anions, (including perchlorate), cations, high explosive (HE) compounds, volatile organic compounds (VOCs), and low-level tritium (LH3). During well development, three samples were collected from the completed well and analyzed for total organic carbon (TOC), metals, cations and anions (including perchlorate). Table 4.2-1 summarizes the screening samples collected during drilling and development of R-30. Groundwater chemistry and field water-quality parameters are discussed in Appendix B.

Further groundwater characterization sampling will be conducted from the completed well in accordance with the Consent Order. For the first year, the samples will be analyzed for the full suite of constituents including radionuclides; anions/cations; general inorganic chemicals; volatile and semivolatile organic compounds; and stable isotopes of hydrogen, nitrogen, and oxygen. The analytical results will be included in the appropriate periodic monitoring report issued by the Laboratory. After the first year, the analytical suite and sample frequency will be evaluated and presented in the annual "Interim Facility-Wide Groundwater Monitoring Plan."

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered from ground surface to 1196.0 ft bgs at R-30 is presented below.

5.1 Stratigraphy

The stratigraphy for the R-30 borehole is presented below. Lithologic descriptions are based on cuttings samples collected from the discharge cyclone. Cuttings and borehole geophysical logs were used to identify geologic contacts. Figure 5.1-1 illustrates the stratigraphy at R-30. A detailed lithologic log based on analysis of drill cuttings is presented in Appendix A.

Quaternary Alluvium, Qal (0 to 5 ft bgs)

Quaternary alluvium occurred from ground surface to 5 ft bgs and consisted of white to pinkish-grey alluvial sediments. These sediments were silt and very fine to fine sand sized sediments with lithic fragments and crystals that were subangular to rounded, moderate to well sorted. The sediments were moderate to highly weathered.

Unit 4, Tshirege Member of the Bandelier Tuff, Qbt 4 (5 to 65 ft bgs)

Unit 4 of the Tshirege Member of the Bandelier Tuff occurred from 5 to 65 ft bgs. Unit 4 consisted of light reddish gray to pale red, poorly to nonwelded, crystal- and lithic-rich ash-flow tuff. The tuff is made up of sparse pumice, crystals, volcanic lithics, and quartz and sanidine phenocrysts in an ashy matrix. Many of the lithic fragments exhibited minor orange-brown oxidation.

Unit 3, Tshirege Member of the Bandelier Tuff, Qbt 3 (65 to 165 ft bgs)

Unit 3 of the Tshirege Member of the Bandelier Tuff occurred from 65 to 165 ft bgs. Unit 3 consisted of light reddish gray to pale red, partly to nonwelded, devitrified, crystal- and lithic-rich ash-flow tuff. The tuff contains volcanic lithics and abundant quartz and sanidine phenocrysts. Unit 3 was slightly indurated near the base.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (165 to 260 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff occurred from 165 to 260 ft bgs. Unit 2 consisted of gray to brown/dark brown to dusky red, moderately to strongly welded, devitrified, crystal-rich ash-flow tuff. The tuff is made up of ash, pumice, volcanic lithics, and quartz and sanidine phenocrysts. Porous purple-gray pumice fragments occurred near the bottom of the unit.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (260 to 350 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff occurred from 260 to 350 ft bgs. Unit 1v consisted of reddish-gray to dusky red to light gray, partly welded to nonwelded, crystal-rich ash-flow tuff. Orange-brown tuff fragments consist of ash, porous purple-gray and light gray pumice fragments, quartz and sanidine phenocrysts, and minor volcanic lithics in an ashy matrix. Orange-brown to pinkish-gray pumice fragments occurred near bottom of the unit.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (350 to 532 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff occurred from 350 to 532 ft bgs. Unit 1g consisted of gray to light brown, poorly to non-welded ash-flow tuff. Light orange-brown tuff fragments contain light orange brown to light pinkish gray, porous/fibrous, glassy, pumice fragments, abundant quartz and sanidine crystals, and volcanic lithics in an ashy matrix.

Cerro Toledo Interval, Qct (532 to 638 ft bgs)

The Cerro Toledo interval occurred from 532 to 638 ft bgs and consisted of light gray to very pale brown, moderately to poorly sorted, poorly graded tuffaceous sedimentary deposits. The deposits were predominantly reworked tuff with some sands, gravels, and cobbles derived from Tschicoma dacites in the Sierra de los Valles highlands west of the Pajarito Plateau. Clasts within this unit were angular to subrounded.

Otowi Member of the Bandelier Tuff, Qbo (638 to 880 ft bgs)

The Otowi Member of the Bandelier Tuff occurred from 638 to 880 ft bgs, and consisted of light gray to light brown to pinkish-gray, glassy, lithic-bearing, pumiceous, poorly to nonwelded ash-flow tuff. It contained light gray to light orange brown, fibrous, vitric pumice fragments and lithic clasts of subangular to subrounded, intermediate composition volcanic rocks. Minor oxidation was present on many pumice and lithic fragments.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (880 to 897 ft bgs)

The Guaje Pumice Bed occurred from 880 to 897 ft bgs. The pumice bed contained a marked increase in light gray to white, fibrous, vitric, pumice fragments (up to 80%) with subordinate amounts of volcanic lithics, quartz and sanidine phenocrysts, with minor oxidation on pumice and lithic fragments.

Puye Formation, Tpf (897 to 1090 ft bgs)

The Puye Formation occurred from 897 to 1090 ft bgs. Cuttings from this formation consisted of light gray to pale red volcaniclastic sediments, with moderately sorted, well-graded subangular to subrounded gravels, sands, and silts composed of volcanic lithics, pumice fragments, and crystals. Fresh angular gravels with remnants of rounded surfaces suggest the borehole penetrated significant deposits of cobbles and boulders that had been milled or pulverized during drilling. Massive deposits of cobbles and boulders were observed in the Puye Formation in video logs collected at nearby well R-29 and other wells in the area.

Cerros del Rio Volcanic Rocks, Tb 4 (1090 to 1110 ft bgs)

The Cerros del Rio volcanic rocks occurred from 1090 to 1110 ft bgs and consisted of aphanitic to porphyritic, nonvesicular to moderately vesicular, scoriaceous intermediate lava containing notable phenocrysts of plagioclase feldspar and clinopyroxene with trace quartz and olivine, both with reaction rims. Fragments were gray to very dark gray with minor reddish-brown oxidation and clay.

Puye Formation, Tpf (1110 to 1196 ft bgs)

Puye Formation occurred from 1110 ft bgs to the borehole TD at 1196 ft bgs. In this interval, the Puye Formation consisted of light gray to very dark gray volcaniclastic sediments. Cuttings from these deposits ranged from poorly to moderately sorted gravels with fine to coarse, subangular to subrounded sands composed of volcanic lithics, scoria, pumice fragments, and crystals. Most fragments exhibited red to red-brown oxidation.

5.2 Groundwater

The Laboratory's borehole video log of the open borehole from 2.6 to 906.0 ft bgs confirmed there were no occurrences of perched water over that interval at R-30. Additionally, there were no indications of perched water from that depth to the regional aquifer.

Regional groundwater was first detected during drilling at 1153.0 ft bgs. The DTW was tagged at 1124.1 ft bgs during drilling activities on March 24. On April 11, following well development, but before aquifer testing began, the composite DTW was recorded at 1124.1 ft bgs.

During the aquifer test of the screened water-bearing zone from 1040.0 to 1060.9 ft bgs, flow rates of approximately 6.5 gallons per minute (gpm) were maintained.

6.0 BOREHOLE LOGGING

During the course of drilling activities, the Laboratory conducted video and geophysical logging to evaluate borehole conditions. Video and geophysical logging runs are summarized in Table 6.0-1.

6.1 Video Logging

Laboratory personnel conducted video logging on March 18, 2010, to a depth of approximately 760 ft bgs to check for perched water. An abundance of foam in the borehole initially obscured the camera lens. The camera was tripped out of the borehole and run again approximately 3 h later to a depth of 906 ft bgs, verifying both the 24-in. and 18-in. casing depths and confirming no occurrences of perched water in the borehole to 905 ft bgs. A summary of these logs is provided in Table 6.0-1. The video log is included on a DVD in Appendix C of this report.

6.2 Geophysical Logging

On March 18, Laboratory personnel conducted natural gamma and induction logging within the R-30 borehole. The natural gamma tool was run to a depth of 1005 ft bgs. The induction tool was run to a depth of 988 ft bgs, at which point it could not be advanced past a ledge. On March 25, Laboratory personnel conducted a natural gamma log of the cased borehole to TD at 1196 ft bgs. The logging is summarized in Table 6.0-1.

7.0 WELL INSTALLATION

The R-30 well was installed between March 26 and April 3, 2010. The following sections provide the well design and a summary of well-construction activities.

7.1 Well Design

The R-30 well was designed in general accordance with the NMED-approved drilling work plan (LANL 2009, 107512). NMED approved the final design before the well was installed. The well was designed with a single screen between 1040.0 to 1060.9 ft bgs to monitor the quality of the regional groundwater in sediments of the Puye Formation.

7.2 Well Construction

The R-30 monitoring well was constructed of 5.0-in.-inside diameter (I.D.)/5.6-in.-O.D., type A304 passivated stainless-steel threaded casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. The screened interval consisted of one 20-ft length of 5.0-in.-I.D. rod-based 0.020-in. wire-wrapped well screen. Compatible external stainless-steel couplings (also type A304 stainless steel fabricated to ASTM A312 standards) were used to join all individual casing and screen sections. The stainless well casing and screen were provided by the Laboratory and were steam-cleaned on-site before they were installed. A 2-in.-I.D. flush-threaded stainless-steel tremie pipe, also steam-cleaned before use, delivered annular backfill materials downhole during well construction. The Schramm T130XD rig used to drill the borehole to TD was also used for well-construction activities. The 20.0-ft-long screen was installed from 1040.0 to 1060.9 ft bgs, with a 10.9-ft stainless-steel sump below the bottom of the screen. Stainless-steel centralizers (two sets of four) were welded to the well casing at 1138.8 and 1161.6 ft bgs, above and below the well screen. Figure 7.2-1 presents an as-built schematic showing construction details and Table 7.2-1 lists the annular fill volumes for well R-30.

Between March 25 and 26, the 5.6-in.-O.D. stainless-steel well casing was moved on-site and decontaminated. Anticipated quantities of backfill materials were also mobilized to the drill site during this time. General preparations were made to begin well construction, and the tremie pipe was tripped into the borehole.

Well construction took place from March 26 to 27. Each casing section was threaded to the string using stainless-steel couplings. On March 27, installation of the 5.6-in.-O.D. well casing in the borehole was completed. The bottom of the well casing was tagged at a depth of 1171.8 ft bgs, and the borehole depth was tagged at 1193.2 ft bgs, indicating 2.8 ft of formational slough in the bottom of the borehole.

Emplacement of annular materials took place from March 27 to April 3. Annular bentonite backfill around the well casing sump was placed from 1193.2 to 1168.0 ft bgs. The bottom seal consisted of 25.1 ft^3 of 0.375-in. hydrated bentonite chips. The primary filter pack surrounding the screen consisted of 32.0 ft^3 of 10/20 clean silica sand emplaced from 1168.0 to 1135.3 ft bgs. After emplacement of the primary filter pack sand, swabbing was conducted just above the screen to promote proper settling of the filter pack.

The fine sand transition collar consisted of 2.0 ft^3 of 20/40 clean silica sand and was emplaced from 1135.3 to 1132.6 ft bgs. All quantities of backfill materials at this point were within 20% of calculated volumes (Figure 7.2-1).

A hydrated bentonite seal was placed above the fine sand collar from 1132.6 to 78.5 ft bgs. The seal consisted of bentonite 0.375-in. chips. The quantity of materials used in this zone was 1337.3 ft^3, about 12% less than the calculated volume of 1526.5 ft^3.

The final surface seal was placed from 78.5 ft bgs to 3.0 ft bgs using a 100 weight percent (wt%) Portland cement seal. The difference between the actual volume used (186.0 ft^3) and the calculated volume (211.4 ft^3) was about 12%. Completion of the grout seal marked R-30 regional monitoring well NMED completion at 0850 h on April 3, 2010.

8.0 POSTINSTALLATION ACTIVITIES

Following well installation, the screened interval was developed through bailing, swabbing, and pumping methods. Following development, an aquifer test was performed on the water-bearing formation at the screened interval by David Schafer and Associates.

8.1 Well Development

Well development was performed with a Semco S15000 pulling unit/workover rig between April 7 and 11, 2010.

Well development began by bailing water and swabbing near the screen, which assists in removing formational fines from around the filter pack and sump. The swabbing tool was a 4.5-in.-diameter, 1-in.-thick rubber disc attached to a weighted-steel rod. The swabbing tool was lowered by wireline and drawn repeatedly across the screened interval. Bailing and swabbing continued until the water clarity visibly improved. Upon completion of bailing and swabbing, well development continued using a 20-horsepower (hp), 4-in.-diameter Grundfos submersible pump. In total, 11,376 gal. of groundwater was pumped from the screened interval during well development.

8.1.1 Well Development Field Parameters

Field parameters of turbidity, temperature, potential of hydrogen (pH), dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance parameters were monitored at R-30 during the pumping stage of well development. In addition, water samples were collected for TOC analysis. TOC should be less than 2.0 ppm, and turbidity should be less than 5 nephelometric turbidity units (NTU) to indicate the well has been developed adequately.

Field parameters were monitored by collecting aliquots of groundwater from the discharge pipe during well development without the use of a flow-through cell, allowing the samples to be exposed to the atmosphere. The flow through cell was not used during development or aquifer testing. Field personnel attempted to use the flow-through cell, but terminated its use because of back pressure on the pump. The exposure of the groundwater discharge to air before field parameters were measured may have caused a slight variation in the values for temperature, pH, ORP, and DO.

The pH measurements varied from 7.7 to 12.3; the large variations indicate the meter was malfunctioning. Temperature varied from 11.3 to 20.0°C, DO varied from 1.3 to 3.9 mg/L, and specific conductance ranged from 113 to 263 microsiemens per centimeter (µS/cm). Corrected oxidation-reduction potential (Eh) values ranged from 182.1 mV to 297.0 mV during well development. Two turbidity readings of 1776 and 1886 NTU were measured at the beginning of well development during the swabbing and bailing phase. Turbidity values ranged from 0.0 to 3.1 NTU over the course of development when a submersible pump was used. The majority of readings recorded during pumping were 0.0 NTU, indicating the meter was malfunctioning. Final accurate field-parameter measurements at the end of development were temperature of 19.0°C and specific conductance of 122 µS/cm. The final TOC concentration at the end of well development was 0.18 mg/L. Table B-1.2-1 in Appendix B presents field parameters and discharge volumes recorded during development.

8.2 Aquifer Testing

Aquifer pumping tests of R-30 were conducted by David Schafer and Associates between April 12 and 15. Two short-duration pumping intervals with short-duration recovery intervals were performed to determine the optimal pumping rate for the 24-h aquifer tests. A 10-hp, 4-in.-diameter Grundfos submersible pump was used to perform the aquifer tests. During the aquifer test, the screen was pumped at a rate of 6.5 gpm, and a total of 9927 gal. of groundwater was purged. Field parameters and purge volumes recorded during aquifer testing are presented in Table B-1.2-1. Data interpretation and analyses of the aquifer tests are presented in Appendix E.

8.3 Dedicated Sampling System Installation

The dedicated sampling system for R-30 was installed on May 18, 2010. The system includes a 4-in.-O.D. Grundfos submersible pump. The pump riser pipe consists of threaded and coupled nonannealed 1-in.-I.D. stainless steel. Two 1-in.-I.D. schedule 80 polyvinyl chloride (PVC) sounder tubes, each with a 1.7-ft section of 0.010-in. slotted screen, were installed alongside of the stainless-steel pipe. These PVC tubes allow for manual water-level measurements and installation of a dedicated In-Situ Level Troll 500 transducer used to collect water-level data over time. Details of the dedicated sampling system are presented in Figures 8.3-1a. Technical specifications of the permanent sampling system are shown in Figure 8.3-1b.

8.4 Wellhead Completion

A reinforced concrete pad, 10 ft ×10 ft × 0.5 ft, was installed at the R-30 wellhead. The pad was slightly elevated above ground surface and crowned to promote runoff. The pad will provide long-term structural integrity for the well. A brass survey monument imprinted with well identification information was embedded in the northwest corner of the pad. A 16-in.-O.D. steel protective casing was installed around the well casing to a depth of 3.0 ft bgs and cemented in place. The protective casing was covered with a mushroom cap with locking bar. A 0.5-in. weep hole was drilled near the base of the protective casing to prevent water accumulation inside the protective casing. A total of four removable bollards, painted bright yellow for visibility, were set approximately 1 ft from each of the pad edges to protect the well from accidental vehicle damage. Details of the wellhead completion are presented in Figure 8.3-1a, and technical notes for R-30 are shown in Figure 8.3-1b.

8.5 Geodetic Survey

A geodetic survey of the wellhead components was conducted by a New Mexico licensed professional land surveyor on June 4, 2010, and the data conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standard for A/E/C and Facility Management.” All coordinates are expressed relative to New Mexico State Plane Coordinate System Central Zone 83 (North American Datum [NAD] 83); elevation is expressed in feet above mean sea level (amsl) using the National Geodetic Vertical Datum of

1929. Survey points included ground-surface elevation near the concrete pad, the top of the brass monument marker in the concrete pad, the top of the well casing, and the top of the protective casing. The survey data are provided in Table 8.5-1, and the location survey report is provided as Appendix F.

8.6 Waste Management and Site Restoration

Waste generated from the R-30 project includes drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected from R-30 is presented in Table 8.6-1.

Waste streams produced during drilling and development activities were sampled in accordance with "Waste Characterization Strategy Form for South Canyon Wells R-29 and R-30 (TA-49, MDA-AB) Regional Groundwater Well Installation and Corehole Drilling" (LANL 2009, 107444).

Fluids produced during drilling and well development are expected to be land-applied after a review of associated analytical results per the waste characterization strategy form (WCSF) and the Standard Operating Procedure (SOP) 010.0, Land Application of Groundwater. If it is determined that drilling fluids are nonhazardous but cannot meet the criteria for land application, the drilling fluids will be evaluated for treatment and disposal at one of the Laboratory's six wastewater treatment facilities. If analytical data indicate the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the drilling fluids will be disposed of at an authorized facility.

Cuttings produced during drilling are anticipated to be land-applied after a review of associated analytical results per the WCSF and ENV-RCRA SOP-011.0, Land Application of Drill Cuttings. If the drill cuttings do not meet the criterion for land application, they will be disposed of at an authorized facility. Decontamination fluid used for cleaning the drill rig and equipment is currently containerized. The fluid waste was sampled and will be disposed of at an authorized facility. Characterization of contact waste will be based upon acceptable knowledge, pending analyses of the waste samples collected from the drill cuttings, purge water, and decontamination fluid.

Site restoration activities will include removing drilling fluids and cuttings from the pit and managing the fluids and cuttings in accordance with the WCSF and ENV-RCRA SOPs. Additionally, the polyethylene liner and containment berms will be removed, and the containment area will be backfilled and reclaimed as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling and sampling at R-30 were performed as specified in "Well R-30 Drill Plan, Installation of Well R-30, TA-49, Los Alamos National Laboratory, Los Alamos, New Mexico" (North Wind, Inc. 2009, 109458). Well construction, development, and testing were also performed as planned.

10.0 ACKNOWLEDGMENTS

Layne Christensen drilled the R-30 borehole and installed the well.

Pat Longmire provided the write-up for Appendix B, Groundwater Analytical Results.

Laboratory personnel ran downhole video and geophysical equipment.

David Schafer and Associates performed the aquifer testing and provided the write-up and data for Appendix E, Aquifer Testing Report.

North Wind, Inc., provided oversight on all preparatory and field-related activities.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 References

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID. The information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's RPF and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), March 2006. "Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan," Los Alamos National Laboratory document LA-UR-06-1840, Los Alamos, New Mexico. (LANL 2006, 092600)

LANL (Los Alamos National Laboratory), October 4, 2007. "Integrated Work Document for Regional and Intermediate Aquifer Well Drilling (Mobilization, Site Preparation and Setup Stages)," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2007, 100972)

LANL (Los Alamos National Laboratory), October 2009. "Drilling Work Plan for Regional Aquifer Well R-30," Los Alamos National Laboratory document LA-UR-09-6383, Los Alamos, New Mexico. (LANL 2009, 107422)

LANL (Los Alamos National Laboratory), October 27, 2009. "Waste Characterization Strategy Form for South Canyon Wells R-29 and R-30 (TA-49, MDA-AB) Regional Groundwater Well Installation and Corehole Drilling," Los Alamos, New Mexico. (LANL 2009, 107444)

North Wind Inc., March 4, 2010. "Well R-30 Drill Plan, Installation of Well R-30, TA-49, Los Alamos National Laboratory," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (North Wind, Inc., 2010, 109458)

11.2 Map Data Sources

Coarse Scale Drainage Arcs; Los Alamos National Laboratory, Water Quality and Hydrology Group of the Risk Reduction and Environmental Stewardship Program; as published 03 June 2003.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

Hypsography, 100 and 20 Ft Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Materials Disposal Area; Los Alamos National Laboratory, RRES Remediation Services Project, ER2004-0221; 1:2,500 Scale Data; 25 April 2004.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

Penetrations; Los Alamos National Laboratory, Environment and Remediation Support Services, ER2006-0664; 1:2,500 Scale Data, 01 July 2006.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning and Project Initiation Group, Infrastructure Planning Division; 19 September 2007.

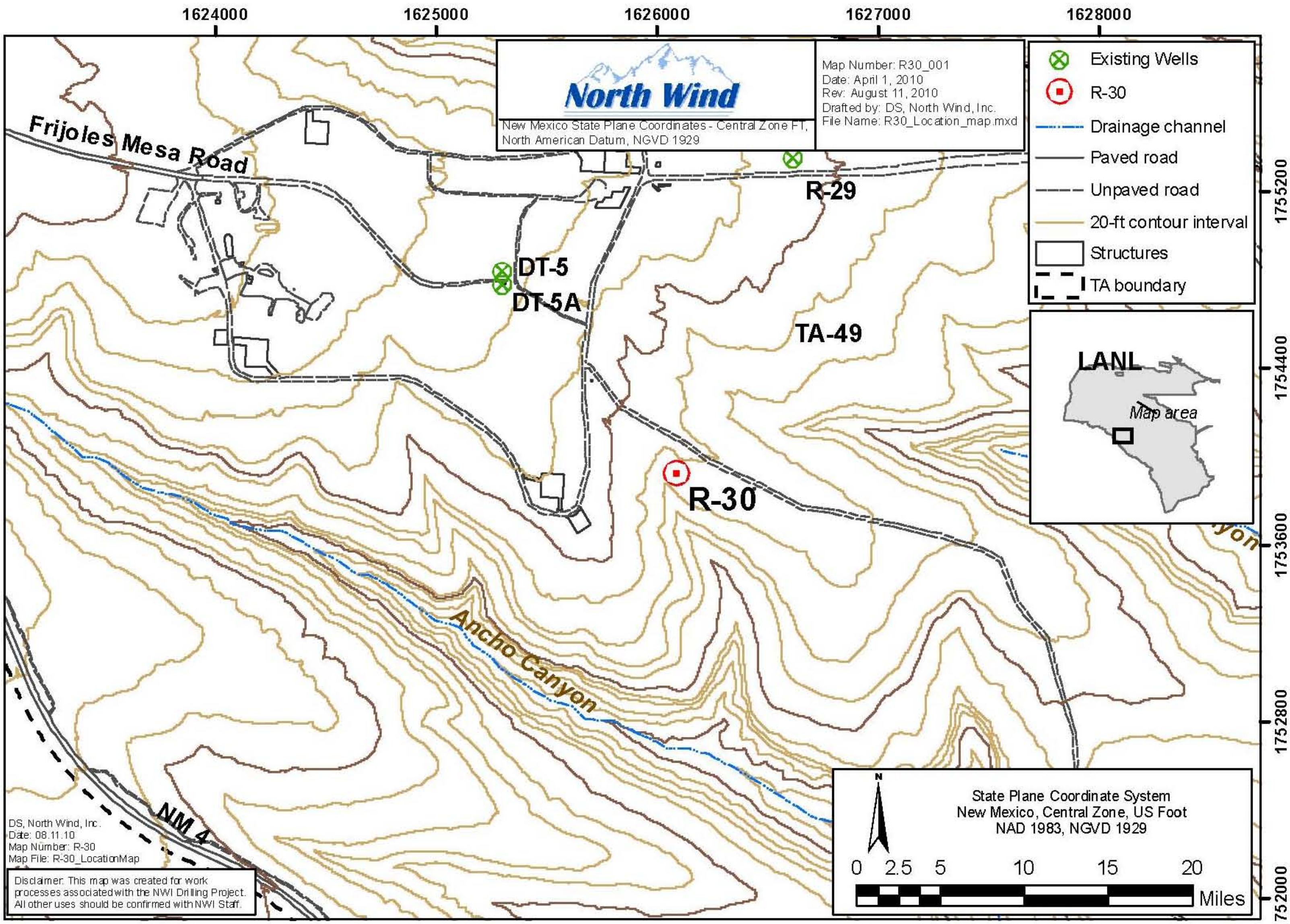

Figure 1.0-1 **Regional aquifer well R-30 location**

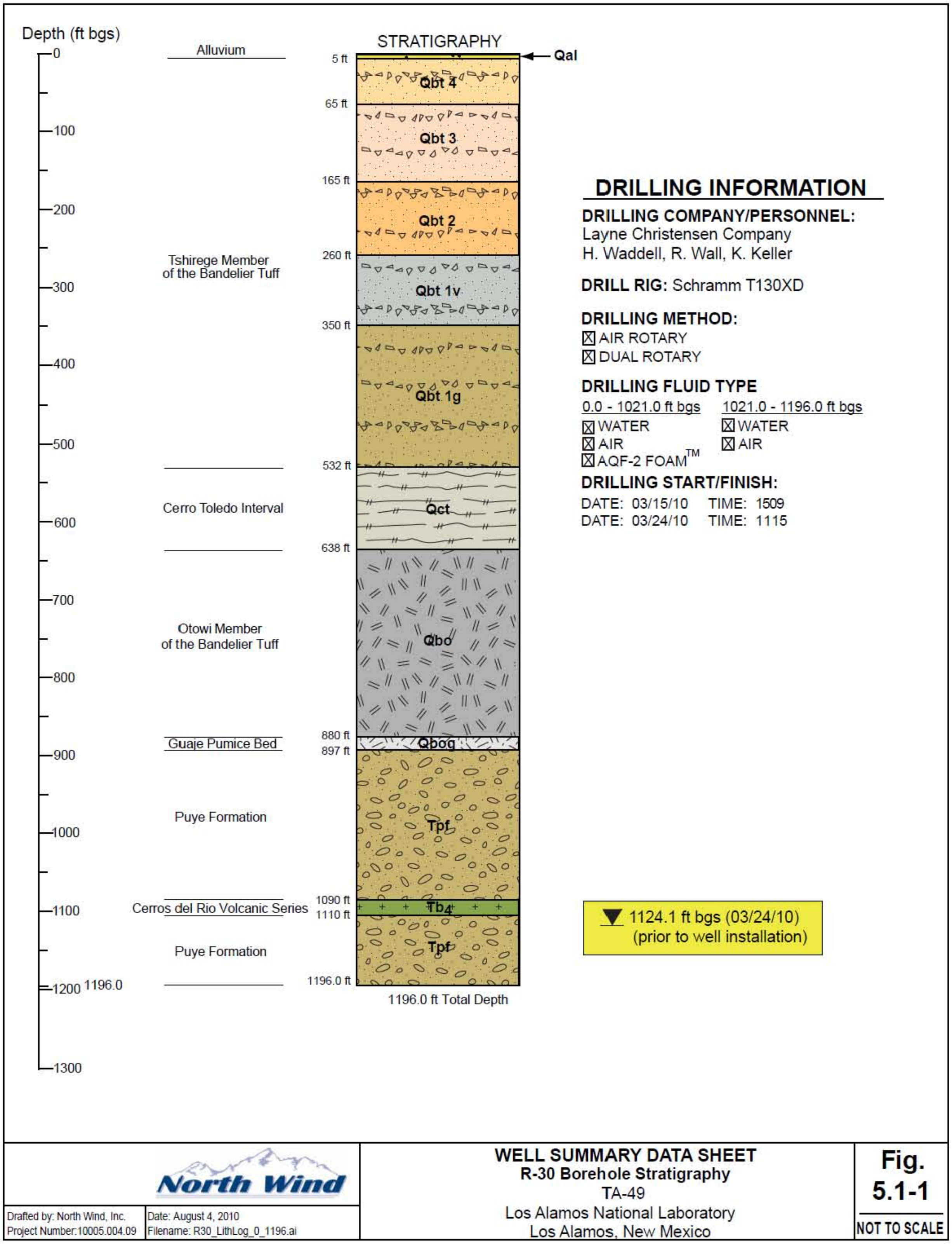

Figure 5.1-1 R-30 borehole stratigraphy

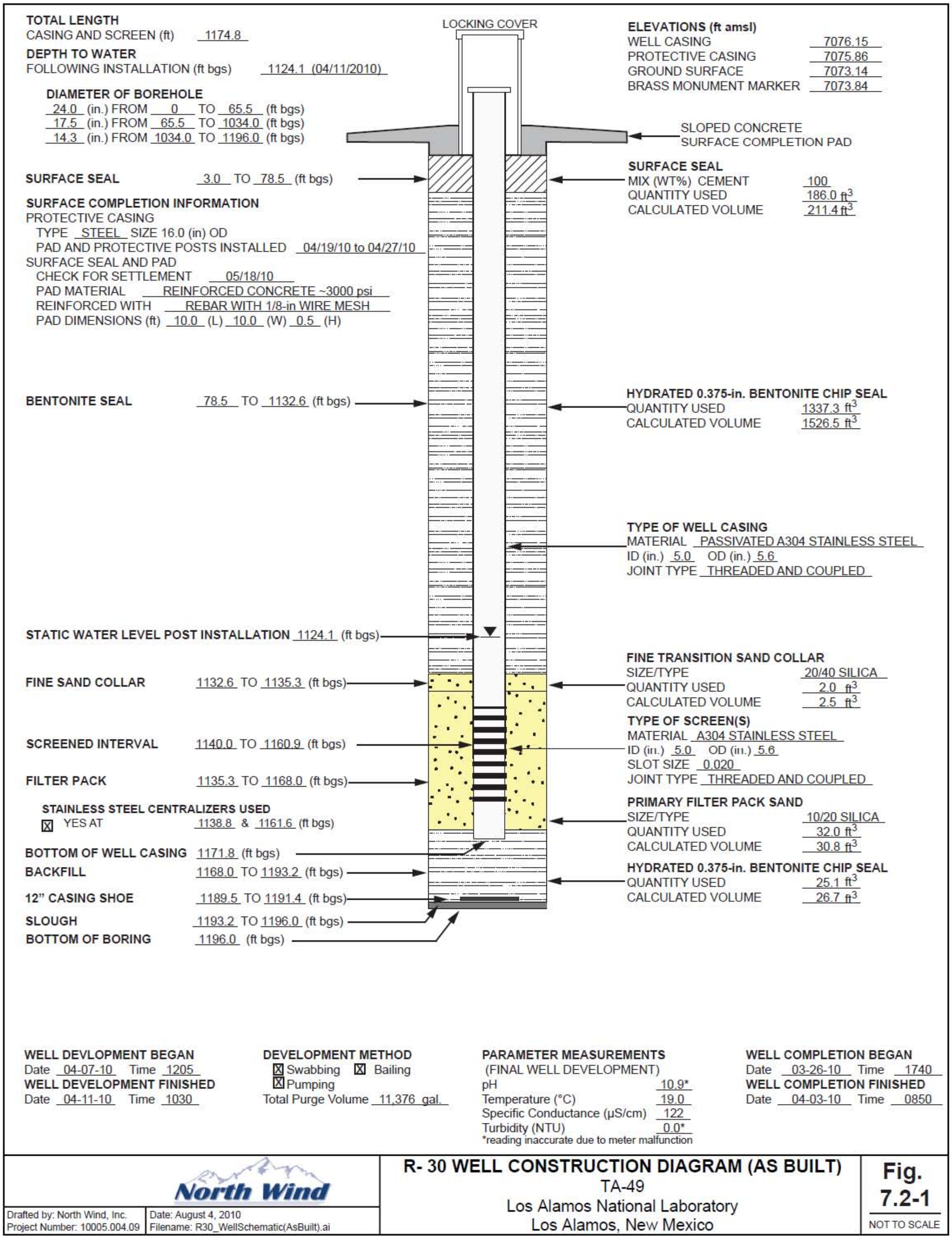

Figure 7.2-1 R-30 as-built well construction diagram

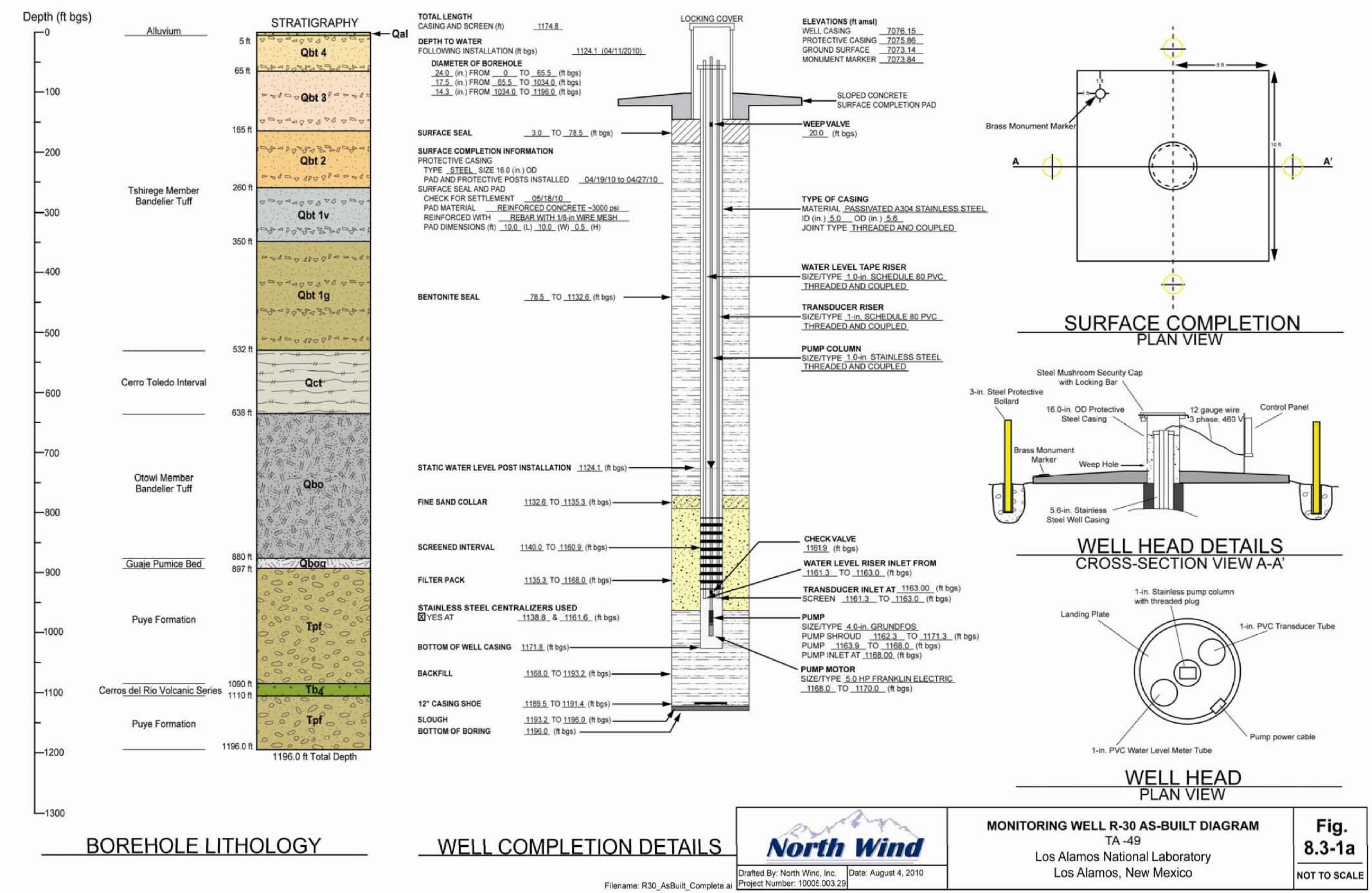

Figure 8.3-1a As-built schematic for regional well R-30

R-30 TECHNICAL NOTES

SURVEY INFORMATION[1]

Brass Marker

Northing:	1753921.18 ft
Easting	1626287.74 ft
Elevation	7073.84 ft amsl

Well Casing (top of stainless steel)

Northing:	1753917.96 ft
Easting:	1626291.65 ft
Elevation:	7076.15 ft amsl

BOREHOLE GEOPHYSICAL LOGS

LANL Gamma and Array Induction Logs (03/18/10)
LANL Gamma (03/25/10)

DRILLING INFORMATION

Drilling Company
Layne Christensen Company

Drill Rig
Schramm T130XD

Drilling Methods
Fluid-assisted air rotary
Fluid-assisted dual rotary

Drilling Fluids
Air
AQF-2 Foam (to 1021.0 ft bgs)
potable water

MILESTONE DATES

Drilling

Start:	03/15/2010
Finish:	03/24/2010

Well Completion

Start:	03/26/2010
Finish:	04/03/2010

Well Development

Start:	04/07/2010
Finish:	04/11/2010

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Volume Purged: 11,376 gal.

Parameter Measurements
(FINAL WELL DEVELOPMENT)

pH:	10.9*
Temperature:	19.0°C
Specific Conductance:	122 µS/cm
Turbidity	0.0 NTU*

*reading inaccurate due to meter malfunction

AQUIFER TESTING

Constant Rate Pumping Test

Water Produced:	9927 gal.
Average Flow Rate:	6.5 gpm
Performed on:	04/12/2010 - 04/15/2010

DEDICATED SAMPLING SYSTEM

Pump Type 10S50-930 CBM
Make: Grundfos
Model: B91126364
SN#: P11015060
5.0 U.S. gpm, intake at 1168.0 ft bgs
Environmental Retrofit

Motor
Make: 5 HP Franklin Electric
Model: 2343278602
SN#: 09K14-30-2985

Pump Column
1-in. ID Threaded/Coupled
Schedule 80 Stainless Steel

Transducer Tube
1-in. ID Flush Threaded Schedule 80 PVC with 1.7-ft long 0.010-in. Screen between 1161.3 - 1163.0 ft bgs

Water Level Tube
1-in. ID Flush Threaded Schedule 80 PVC
Screen between 1161.3 - 1163.0 ft bgs

Transducer
Installed 05/18/2010
Make: In-Situ
Model: Level Troll 500

NOTES:
1) Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD 83);
Elevation expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

North Wind

Drafted by: North Wind, Inc.
Project Number:10005.003.29
Date: August 4, 2010

R-30 TECHNICAL NOTES
TA-49
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig. 8.3-1b

Figure 8.3-1b Technical notes for regional well R-30

Table 3.1-1
Fluid Quantities Used during R-30 Drilling and Well Construction

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
3/15/2010	1250	1250	n/a*	n/a
3/16/2010	8210	9460	11	11
3/17/2010	17,500	26,960	130	141
3/21/2010	8000	34,960	n/a	n/a
3/23/2010	5000	39,960	300	441
3/24/2010	750	40,710	n/a	n/a
3/25/2010	200	40,910	n/a	n/a
3/27/2010	2700	43,610	n/a	n/a
3/28/2010	6200	49,810	n/a	n/a
3/29/2010	6600	56,410	n/a	n/a
3/30/2010	9000	65,410	n/a	n/a
3/31/2010	20,800	86,210	n/a	n/a
4/1/2010	26,000	112,210	n/a	n/a
4/2/2010	37,450	149,660	n/a	n/a
4/3/2010	580	150,240	n/a	n/a
Total Water Volume				
R-30	150,240 gal.			

* n/a = Not applicable.

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Drilling, Well Development, and Aquifer Testing of Well R-30

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
R-30	GW30-10-14925	3/24/10	1138	Groundwater (airlifted)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
R-30	GW30-10-14926	3/25/10	1195	Groundwater (airlifted)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
Well Development					
R-30	GW30-10-14920	4/9/10	1160	Groundwater (air lifted)	TOC, metals, cations, anions
R-30	GW30-10-14921	4/10/10	1160	Groundwater (air ifted)	TOC, metals, cations, anions including perchlorate)
R-30	GW30-10-14929	4/10/10	1160	Groundwater (airlifted)	TOC, metals, cations, anions (including perchlorate)

.

Table 6.0-1
R-30 Video and Geophysical Logging

Date	Depth (ft bgs)	Description
3/18/010	0–1005	LANL natural gamma log run to 1005 ft bgs.
3/18/010	0–988	LANL induction log run to a depth of 988 ft bgs, at which point it could not be advanced past a ledge.
3/18/010	0–905	LANL video log run down the open borehole to a depth of about 760 ft bgs. The camera was run a second time to a depth of 906 ft bgs. Confirmed both the 24-in. and 18-in. casing depths. Confirmed no perched water in the borehole to 905 ft bgs.
3/25/010	0–1196	LANL natural gamma log run.

Table 7.2-1
R-30 Annular Fill Materials

Material	Volume (ft^3)
Surface seal: 100 wt% Portland cement	186.0
Upper seal: 0.375-in. bentonite chips	1,337.3
Transition sand collar: 20/40 silica sand	2.0
Primary filter pack: 10/20 silica sand	32.0
Lower seal: 0.375-in. bentonite chips	25.1

Table 8.5-1
R-30 Survey Coordinates

Identification	Northing	Easting	Elevation
R-30 brass monument marker	1753921.18	1626287.74	7073.84
R-30 ground surface	1753925.49	1626278.97	7073.14
R-30 top of protective casing	1753917.93	1626291.59	7075.86
R-30 top of well casing	1753917.96	1626291.65	7076.15

Note: All coordinates expressed as New Mexico State Plan Coordinate System Central Zone Feet (NAD 83); elevation expressed in feet amsl using the National Geodetic Vertical Datum of 1929. Surveying was completed on June 4, 2010.

Table 8.6-1
Summary of Waste Samples Collected during Drilling and Development of R-30

Sample ID/Event ID	Date, Time Collected	Description	Sample Matrix
WST30-10-15466/2735	4/9/10, 1335	Decon Water	Liquid
WST30-10-15467/2735	4/9/10, 1335	Trip Blank	Liquid
WST30-10-15607/2742	4/14/10, 1135	Development Water	Liquid
WST30-10-15608/2742	4/14/10, 1135	Development Water	Liquid
WST30-10-15609/2742	4/14/10, 1135	Development Water	Liquid
WST30-10-15610/2742	4/14/10, 1135	Trip Blank	Liquid
WST30-10-15858/2761	4/14/10, 1015	Trip Blank	Liquid
WST30-10-15859/2761	4/14/10, 1010	Decon Water	Liquid
WST30-10-15860/2762	4/14/10, 1020	Trip Blank	Liquid
WST30-10-15861/2762	4/14/10, 1020	Decon Water	Liquid
WST30-10-15912/2768	4/16/10, 1500	Trip Blank	Soil
WST30-10-15913/2768	4/16/10, 1500	Drill Cuttings	Soil
WST30-10-16643/2791	4/26/10, 1200	Development Water	Liquid
WST30-10-16644/2791	4/26/10, 1200	Development Water	Liquid
WST30-10-16645/2791	4/26/10, 1200	Development Water	Liquid
WST30-10-16646/2791	4/26/10, 1200	Trip Blank	Liquid

Appendix A

Well R-30 Borehole Lithologic Log

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

Borehole Identification (ID): R-30	**Technical Area (TA):** 49	**Page:** 1 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
0–5	**QUATERNARY ALLUVIUM:** Silt and very fine to fine sand-size alluvial sediments (ML) with lithic fragments and crystals that are subangular to rounded, moderately to well sorted, white (7.5YR8/1) to pinkish grey (7.5YR7/2). WR: Very fine to fine sand-size alluvial sediments with 5–10% lithic fragments and crystals. +10F: No +10 sieve samples retained. +35F: 35% crystals (including quartz and quartz with inclusions), 65% lithic fragments.	**Qal**	Note: Base-course gravel also noted.
5–15	**UNIT 4 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, white (7.5YR8/1) to pinkish grey (7.5YR7/2), nonwelded, crystal- and lithic-rich tuff fragments (ash and sparse pumice, crystals, and lithics), volcanic lithics, and quartz and sanidine crystals in an ashy/sandy matrix. +10F: No +10 sieve sample retained. +35F: 65% tuff fragments and volcanic lithics, 65% quartz and sanidine crystals.	**Qbt 4**	
15–20	No cuttings returned in this interval.		
20–35	Tuff, light reddish gray (2.5YR7/1) to pale red (2.5YR5/2), partly to nonwelded, crystal- and lithic-rich tuff fragments (ash and sparse pumice, crystals, and lithics), volcanic lithics, and quartz and sanidine crystals in an ashy/sandy matrix. Fragments of tuff have an ashy/sandy texture. +10F: 90–95% tuff fragments, 5–10% volcanic lithics, trace quartz and sanidine crystals (inclusions in quartz noted). +35F: 25–40% tuff fragments, 5–10% volcanic lithics, 50–70% quartz and sanidine crystals.	**Qbt 4**	

Borehole Identification (ID): R-30	Technical Area (TA): 49	Page: 2 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
35–50	Tuff, light reddish gray (2.5YR7/1) to pale red (2.5YR5/2), partly to nonwelded, crystal- and lithic-rich tuff fragments (ash and sparse pumice, crystals, and lithics), volcanic lithics, and quartz and sanidine crystals. Minor orange-brown oxidation on some fragments. +10F: 65–90% tuff fragments, 2–7% volcanic lithics, 3–30% quartz and sanidine crystals. +35F: 5–30% tuff fragments, 5–10% volcanic lithics, 65–90% quartz and sanidine crystals. (Bipyramidal quartz, quartz with inclusions, and trace obsidian noted.)	**Qbt 4**	
50–65	Tuff, light reddish gray (2.5YR7/1) to pale red (2.5YR5/2), partly to nonwelded, crystal and lithic rich tuff fragments (ash and sparse pumice, crystals, and lithics), volcanic lithics, and abundant quartz and sanidine crystals. +10F: 40% tuff fragments, 10% volcanic lithics, 50% quartz and sanidine crystals. +35F: 10% tuff fragments, 10% volcanic lithics, 80% quartz and sanidine crystals. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 4**	
65–75	**UNIT 3 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, light reddish gray (2.5YR7/1) to pale red (2.5YR5/2), partly to nonwelded, crystal- and lithic-rich devitrified tuff fragments (ash and pumice, crystals, and lithics), volcanic lithics, and abundant quartz and sanidine crystals. +10F: 40–65% tuff fragments, 5–10% volcanic lithics, 25–55% quartz and sanidine crystals. +35F: 10–15% tuff fragments, 75–85% quartz and sanidine crystals, 3–5% volcanic lithics. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 3**	Note: Contact determined based on shift on gamma log. No apparent significant shift in cutting descriptions.
75–90	Tuff, light reddish gray (2.5YR7/1) to pale red (2.5YR5/2), partly to nonwelded, crystal- and lithic-rich devitrified tuff fragments (ash and pumice, crystals, and lithics), volcanic lithics, and abundant quartz and sanidine crystals. +10F: 80–85% tuff fragments, 3–7% volcanic lithics, 8–12% quartz and sanidine crystals. +35F: 10–15% tuff fragments, 3–5% volcanic lithics, 70–85% quartz and sanidine crystals. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 3**	

Borehole Identification (ID): R-30	**Technical Area (TA):** 49	**Page:** 3 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
90–110	Tuff, light reddish gray (2.5YR7/1) to dark gray (5YR5/1), partly welded/slightly indurated, crystal- and lithic-rich devitrified tuff fragments (ash and pumice, crystals, and lithics), volcanic lithics, and abundant quartz and sanidine crystals. +10F: 25–50% tuff fragments, 45–65% volcanic lithics, 5–10% quartz and sanidine crystals. +35F: 4–7% tuff fragments, 3–5% volcanic lithics, 90–93% quartz and sanidine crystals. (Bipyramidal quartz, quartz with inclusions, and glass shards noted.)	**Qbt 3**	
110–115	Tuff, same as above (90–110 ft bgs) with increase in quartz and sanidine crystals in +10F: 25% quartz and sanidine crystals.	**Qbt 3**	
115–130	Tuff, light reddish gray (2.5YR7/1) to dark gray (5YR5/1), partly welded/slightly indurated, crystal- and lithic-rich devitrified tuff fragments (ash and pumice, crystals, and lithics), volcanic lithics, and abundant quartz and sanidine crystals. +10F: 15–30% tuff fragments (whitish gray to light orange-brown in color), 50–65% volcanic lithics, 10–20% quartz and sanidine crystals. +35F: 5–10% tuff fragments, 5–10% volcanic lithics, 85–90% quartz and sanidine crystals. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 3**	
130–155	Tuff, light reddish gray (2.5YR7/1) to dark gray (5YR5/1), minor partly welded/slightly indurated, crystal- and lithic-rich devitrified tuff fragments (ash and pumice, crystals, and lithics), volcanic lithics, and abundant quartz and sanidine crystals. +10F: 7–15% tuff fragments (whiteish gray to light orange-brown in color), 60–75% volcanic lithics, 10–20% quartz and sanidine crystals. +35F: 5–10% pumice fragments, 5–10% volcanic lithics, 80–90% quartz and sanidine crystals. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 3**	

Borehole Identification (ID): R-30	Technical Area (TA): 49	Page: 4 of 18	
Drilling Company: Layne Christensen Co.	Start Date/Time: 03/15/10 1945	End Date/Time: 03/24/10 1115	
Drilling Method: Air Rotary	Machine: Schramm T130XD RIG T25	Sampling Method: Grab	
Ground Elevation: 7073.14		Total Depth: 1196 ft bgs	
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	Site Geologists: T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman		

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
155–165	Tuff, light reddish gray (2.5YR7/1) to dark gray (5YR5/1), minor poorly to nonwelded, crystal- and lithic-rich devitrified tuff fragments (ash and pumice, crystals, and lithics), volcanic lithics, and abundant quartz and sanidine crystals. +10F: 30–40% tuff fragments (whiteish gray to light orange-brown in color in addition to porous, crystal rich light purplish-gray fragments), 45–55% volcanic lithics, 5–10% quartz and sanidine crystals. +35F: 3–5% tuff fragments, 2–5% volcanic lithics, 90–95% quartz and sanidine crystals. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 3**	
165–170	**UNIT 2 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, gray (7.5YR6/1) to dark brown (7.5YR3/2), moderately to strongly welded/indurated, devitrified, crystal-rich tuff fragments (ash and pumice, crystals, and minor lithics), volcanic lithics, and quartz and sanidine crystals. +10F: 75% tuff fragments, 10% volcanic lithics, 15% quartz and sanidine crystals. +35F: 10% tuff fragments, 85% quartz and sanidine crystals, 5% volcanic lithics. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 2**	Note: Contact determined, in part, based on shift on gamma log and appearance of moderately to strongly welded tuff fragments indicative of Qbt 2. Significant increase in tuff fragments and decrease in quartz and sanidine crystals.
170–185	Tuff, gray (7.5YR6/1) to dark brown (7.5YR3/2), moderately to strongly welded/indurated, devitrified, devitrified crystal-rich tuff fragments (ash and pumice, crystals, and minor lithics), and minor volcanic lithics and quartz and sanidine crystals in ashy matrix. +10F: 92–97% tuff fragments, 0–3% volcanic lithics, 0–5% quartz and sanidine crystals. +35F: 80–90% tuff fragments, 2–5% volcanic lithics, 5–20% quartz and sanidine crystals. (Bipyramidal quartz and quartz with inclusions noted.)	**Qbt 2**	

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Drilling Company: Layne Christensen Co.	Start Date/Time: 03/15/10 1945	End Date/Time: 03/24/10 1115
Drilling Method: Air Rotary	Machine: Schramm T130XD RIG T25	Sampling Method: Grab
Ground Elevation: 7073.14		Total Depth: 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	Site Geologists: T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
185–240	Tuff, gray (7.5YR6/1) to brown (7.5YR4/2), moderately to strongly welded/indurated, devitrified, crystal-rich tuff fragments (ash and pumice, crystals, and minor lithics), and minor volcanic lithics and quartz and sanidine crystals in ashy matrix. Evidence of flattened pumices in tuff fragments. +10F: 98–100% tuff fragments, 0–2% volcanic lithics, 0–1% quartz and sanidine crystals. +35F: 80–90% tuff fragments, 2–3% volcanic lithics, 8–18% quartz and sanidine crystals. (Bipyramidal quartz and quartz with inclusions noted.)	Qbt 2	
240–260	Tuff, reddish gray (5YR5/2) to dusky red (2.5YR3/2), partly to strongly welded, devitrified crystal-rich tuff fragments (ash and pumice, crystals, and minor lithics), and minor volcanic lithics and quartz and sanidine crystals in ashy matrix. Appearance of purple-gray, porous, pumice fragments. +10F: 98–100% tuff and pumice fragments, 0–1% volcanic lithics, 0–2% quartz and sanidine crystals. +35F: 80–90% tuff and pumice fragments, 1–2% volcanic lithics, 8–20% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	Qbt 2	
260–280	**UNIT 1v OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, reddish gray (5YR5/2) to dusky red (2.5YR3/2), nonwelded to moderately welded, devitrified crystal-rich orange-brown tuff fragments (ash and pumice, crystals, and minor lithics), purple-gray and light gray, porous, pumice fragments, quartz and sanidine crystals, and minor volcanic lithics in ashy matrix. +10F: 95–97% tuff and pumice fragments, 1–3% volcanic lithics, 0–2% quartz and sanidine crystals. +35F: 60–85% tuff and pumice fragments, 2–5% volcanic lithics, 15–35% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted).	Qbt 1v	Note: Contact determined based on shift on gamma log.

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
280–285	Tuff, light gray (5YR7/1) to gray (5YR5/1), nonwelded to partly welded, devitrified crystal-rich orange-brown tuff fragments (ash and pumice, crystals, and minor lithics), light gray, porous/fibrous, pumice lapilli fragments, abundant quartz and sanidine crystals, and minor volcanic lithics. +10F: 91% tuff and pumice fragments, 2% volcanic lithics, 7% quartz and sanidine crystals. +35F: 20% tuff and pumice fragments, 5% volcanic lithics, 75% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1v**	Note: Marked increase in quartz and sanidine content in WR and +35F samples.
285–300	Tuff, gray (5YR6/1) to dark gray (5YR4/1), nonwelded to partly welded, devitrified crystal-rich orange-brown tuff fragments (ash and pumice, crystals, and minor lithics), light gray to light orange-brown and light purple-gray, porous/fibrous, pumice lapilli fragments, abundant quartz and sanidine crystals, and volcanic lithics. +10F: 65–70% tuff and pumice fragments, 15–25% volcanic lithics, 5–10% quartz and sanidine crystals. +35F: 2–5% tuff and pumice fragments, 2–3% volcanic lithics, 90–92% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1v**	Note: Marked increase in lithic fragments in +10F.
300–305	No cuttings returned in this interval.	**Qbt 1v**	
305–320	Tuff, gray (5YR6/1) to dark gray (5YR4/1), minor nonwelded to partly welded, devitrified crystal-rich orange-brown tuff fragments (ash and pumice, crystals, and minor lithics), minor light gray, porous/fibrous, pumice lapilli fragments, abundant quartz and sanidine crystals, and abundant volcanic lithics. +10F: 25–45% tuff and pumice fragments, 55–65% volcanic lithics, 5–10% quartz and sanidine crystals. +35F: 5–7% tuff and pumice fragments, 3–5% volcanic lithics, 88–92% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted).	**Qbt 1v**	
320–330	No cuttings returned in this interval.	**Qbt 1v**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
330–340	Tuff, gray (5YR6/1) to light gray (7.5YR6/4), nonwelded to partly welded, devitrified crystal-rich light orange-brown tuff fragments (ash and abundant pumice, crystals, and minor lithics), light orange-brown to light pinkish-gray, porous/fibrous, pumice lapilli fragments, abundant quartz and sanidine crystals, and abundant volcanic lithics in pink-ish white ashy matrix. +10F: 25–30% tuff and pumice fragments, 55–65% volcanic lithics, 5–10% quartz and sanidine crystals. +35F: 30–35% tuff and pumice fragments, 5–10% volcanic lithics, 35–55% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1v**	Note: Marked increase in light orange-brown to light pink-ish gray pumice content.
340–350	Tuff, gray (5YR6/1) to light gray (7.5YR6/4), nonwelded to partly welded, devitrified crystal-rich light orange-brown tuff fragments (ash and abundant pumice, crystals, and minor lithics), light orange-brown to light pinkish-gray, porous/fibrous, pumice lapilli fragments, abundant quartz and sanidine crystals, and abundant volcanic lithics in pinkish white ashy matrix. +10F: 70–80% tuff and pumice fragments, 10–15% volcanic lithics, 3–5% quartz and sanidine crystals. +35F: 40–50% tuff and pumice fragments, 5–10% volcanic lithics, 35–40% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1v**	
350–360	**UNIT 1g OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, gray (5YR6/1) to light brown (7.5YR6/4), nonwelded to partly welded, light orange-brown tuff fragments (ash and abundant pumice, crystals, and minor lithics), light orange-brown to light pinkish-gray, porous/fibrous, vitric pumice lapilli fragments, abundant quartz and sanidine crystals, and abundant volcanic lithics in pinkish white ashy matrix. +10F: 55–65% tuff and pumice fragments, 25–30% volcanic lithics, 3–5% quartz and sanidine crystals. +35F: 35–40% tuff and pumice fragments, 5–10% volcanic lithics, 40–50% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1g**	Note: Contact determined based on first appearance of volcanic glass and shift on gamma log.
360–370	No cuttings returned in this interval.	**Qbt 1g**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
370–380	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), nonwelded, minor light orange-brown tuff fragments (ash and abundant vitric pumice, crystals, and minor lithics), abundant light orange-brown, porous/fibrous, pumice lapilli fragments, abundant quartz and sanidine crystals, and abundant volcanic lithics in ashy matrix. +10F: 55–65% tuff and pumice fragments, 35–40% volcanic lithics, 3–5% quartz and sanidine crystals. +35F: 30–35% tuff and pumice fragments, 10–15% volcanic lithics, 40–50% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1g**	
380–390	No cuttings returned in this interval.	**Qbt 1g**	
390–395	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), minor nonwelded, light orange-brown tuff fragments (ash and abundant vitric pumice, crystals, and minor lithics), abundant light orange-brown to light gray, glassy, porous and fibrous, pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. Black obsidian noted in some pumice fragments. +10F: 100% pumice and tuff fragments, 0% volcanic lithics, 0% quartz and sanidine crystals. +35F: 82% pumice and tuff fragments, 3% volcanic lithics, 15% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1g**	
395–415	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), minor nonwelded, light orange-brown tuff fragments (ash and abundant vitric pumice, crystals, and minor lithics), abundant light orange-brown to light gray, glassy, porous and fibrous, pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. Black obsidian noted in some pumice fragments. +10F: 65–80% pumice and tuff fragments, 15–30% volcanic lithics, 0% quartz and sanidine crystals. +35F: 30–40% pumice and tuff fragments, 5–10% volcanic lithics, 45–60% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1g**	

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
415–435	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), minor nonwelded, light orange-brown tuff fragments (ash and abundant vitric pumice, crystals, and minor lithics), abundant light gray to white, glassy, porous and fibrous, pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. +10F: 54–65% pumice and tuff fragments, 35–45% volcanic lithics, 1–3% quartz and sanidine crystals. +35F: 5–10% pumice and tuff fragments, 5–10% volcanic lithics, 75–85% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1g**	
435–440	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), abundant light gray to white, glassy, porous and fibrous, vitric pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. +10F: 85% pumice fragments, 14% volcanic lithics, 1% quartz and sanidine crystals. +35F: 43% pumice fragments, 2% volcanic lithics, 55% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1g**	
440–445	No cuttings returned in this interval.	**Qbt 1g**	
445–465	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), abundant light gray to white, glassy, porous and fibrous, vitric pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. +10F: 60–70% pumice fragments, 35–45% volcanic lithics, 0% quartz and sanidine crystals. +35F: 30–45% pumice fragments, 2–5% volcanic lithics, 35–60% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.)	**Qbt 1g**	
465–480	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), abundant light gray to white, glassy, porous and fibrous, vitric pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. +10F: 35–50% pumice fragments, 50–65% volcanic lithics, 1% quartz and sanidine crystals. +35F: 13–45% pumice fragments, 2–5% volcanic lithics, 50–85% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.) Minor red-brown oxidation on pumice fragments.	**Qbt 1g**	

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Drilling Method: Air Rotary		**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab	
Ground Elevation: 7073.14			**Total Depth:** 1196 ft bgs	
Driller: H. Waddell, K. Keller, R. Wall, J. Allen		**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman		
Depth (ft bgs)	**Lithology**		**Lithologic Symbol**	**Notes**
480–495	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), abundant light gray to white, glassy, porous and fibrous, vitric pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. +10F: 70–80% pumice fragments, 20–29% volcanic lithics, 1% quartz and sanidine crystals. +35F: 40–45% pumice fragments, 3–7% volcanic lithics, 45–55% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.) Red-brown oxidation on pumice fragments.		**Qbt 1g**	
495–500	Tuff, same as above (480–495 ft bgs) with increase in lithic fragments from 10–12 mm in diameter in +10F: 70%.		**Qbt 1g**	
500–525	Tuff, gray (5YR6/1) to light brown (7.5YR6/4), abundant light gray to white, glassy, porous and fibrous, vitric pumice lapilli fragments, quartz and sanidine crystals, and volcanic lithics in ashy matrix. +10F: 65–80% pumice fragments, 20–33% volcanic lithics, 1–2% quartz and sanidine crystals. +35F: 40–45% pumice fragments, 3–7% volcanic lithics, 45–55% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.) Red-brown oxidation on pumice fragments.		**Qbt 1g**	
525–532	Tuff, light gray (7.5YR7/1) to gray (5YR6/1), abundant light gray to white, glassy, porous and fibrous, vitric pumice lapilli fragments, abundant quartz and sanidine crystals, and volcanic lithics in ashy matrix. +10F: 65–80% pumice fragments, 25–33% volcanic lithics, 1–2% quartz and sanidine crystals. +35F: 10–15% pumice fragments, 3–5% volcanic lithics, 85–95% quartz and sanidine crystals. (Bipyramidal quartz and inclusions in quartz noted.) Red-brown oxidation on pumice fragments.		**Qbt 1g**	Note: Marked increase in quartz and sanidine crystals. Contact between Qbt 1g and Qct at 532 ft bgs corresponds with significant shift on gamma log.

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
532–540	**CERRO TOLEDO INTERVAL:** Volcaniclastic sediments, light gray (10YR7/1) to very pale brown (10YR7/3), moderately to poorly sorted, poorly graded with sand (GM), fine to coarse sand, grains angular to subrounded. +10F: detritral constituents (up to 10–12 mm) composed of 15% felsic-intermediate composition volcanic lithics, 85% white to light red orange-brown fibrous pumice fragments, no quartz and sanidine crystals. +35F: 10% volcanic lithics, 20% vitric pumice fragments, 70% quartz and sanidine.	**Qct**	
540–550	Volcaniclastic sediments, light gray (10YR7/1) to very pale brown (10YR7/3), moderately sorted, poorly graded with sand (GM), fine to coarse sand, grains angular to subrounded. +10F: detritral constituents (up to 8 mm) composed of 60–75% felsic-intermediate composition volcanic lithics (including tuffaceous sandstone), 25–30% white to light reddish-brown fibrous, vitric and devitrified pumice fragments, no quartz and sanidine crystals. +35F: 10–15% volcanic lithics, 25–35% vitric pumice fragments, 55–60% quartz and sanidine.	**Qct**	
550–590	Volcaniclastic sediments, light gray (7.5YR7/1) to very dark gray (5YR3/1), moderately to poorly sorted, well graded with sand (GW), fine to coarse sand, grains angular to subrounded. +10F: detrital constituents (up to 12 mm) include 94–96% felsic-intermediate composition volcanic lithics (including dacite and tuffaceous sandstone), 3–5% white to reddish-orange vitric and devitrified pumice fragments, 1–2% quartz and sanidine. +35F: 25–35% volcanic lithics, 30–35% vitric pumice fragments, 35–40% quartz and sanidine. Orange-brown oxidation on most pumice fragments.	**Qct**	
590–595	As above (550–590 ft bgs) with increase in pumice fragments in +10F: 40%.	**Qct**	

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
595–600	Volcaniclastic sediments, light gray (7.5YR7/1) to very dark gray (5YR3/1), moderately to poorly sorted, well graded with sand (GW), fine to coarse sand, grains angular to subrounded. +10F: detrital constituents (up to 10 mm) include 94–96% felsic-intermediate composition volcanic lithics (including dacite and tuffaceous sandstone), 3–5% white to reddish-orange vitric and devitrified pumice fragments, 1–2% quartz and sanidine. +35F: 25–35% volcanic lithics, 30–35% vitric pumice fragments, 35–40% quartz and sanidine. Orange-brown oxidation on most pumice fragments.	**Qct**	
600–638	Volcaniclastic sediments, dark gray (5YR4/1), moderately sorted, well graded with sand (GW), medium to coarse sand, grains subangular to subrounded. +10F: detrital constituents (up to 12 mm) include 55–75% felsic-intermediate composition volcanic lithics (including dacite and tuffaceous sandstone), 25–45% light gray to orange-brown vitric and devitrified pumice fragments. +35F: 55–60% volcanic lithics, 10–25% vitric pumice fragments, 20–30% quartz and sanidine. Orange-brown oxidation on most clasts.	**Qct**	
638–640	**OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, light gray (7.5YR7/1) to light brown (7.5YR6/4), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 10 mm), and crystals in an ashy matrix. WR: ashy/sandy texture. +10F: 95% pumice fragments, 5% volcanic lithics. +35F: 76% pumice fragments, 10% volcanic lithics, 15% quartz and sanidine crystals (trace obsidian noted).	**Qbo**	Note: Contact between Qct and Qbo at 638 ft bgs corresponds with significant shift on gamma log.
640–690	Tuff, light gray (7.5YR7/1) to light brown (7.5YR6/4), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 10 mm), and crystals in an ashy matrix. +10F: 25%–35% pumice fragments, 65%–75% volcanic lithics, trace to no quartz and sanidine. +35F: 15%–20% pumice fragments, 25%–30% volcanic lithics, 30%–55% quartz and sanidine crystals (trace obsidian noted).	**Qbo**	

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
690–700	Tuff, light gray (7.5YR7/1) to pink (7.5YR7/3), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 10 mm), and crystals in an ashy matrix. +10F: 3–5% pumice fragments, 95–97% volcanic lithics. +35F: 3–5% pumice fragments, 50–55% volcanic lithics, 40–45% quartz and sanidine crystals.	**Qbo**	
700–720	Tuff, light gray (7.5YR7/1) to pinkish gray (7.5YR6/2), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 5 mm), and crystals in an ashy matrix. +10F: 30–45% pumice fragments, 55–70% volcanic lithics. +35F: 35–40% pumice fragments, 45–60% volcanic lithics, 5–15% quartz and sanidine crystals.	**Qbo**	
720–725	As above (550–590) with increase in quartz and sanidine crystals in +10F: 55%.	**Qbo**	
725–735	Tuff, light gray (7.5YR7/1) to pinkish gray (7.5YR6/2), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 5 mm), and crystals in an ashy matrix. +10F: 55–60% pumice fragments, 40–45% volcanic lithics. +35F: 45–55% pumice fragments, 35–45% volcanic lithics, 5–15% quartz and sanidine crystals.	**Qbo**	
735–740	Tuff, light gray (7.5YR7/1) to pinkish gray (7.5YR6/2), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics, and crystals in an ashy matrix. +10F: 95% pumice fragments, 5% volcanic lithics. +35F: 85% pumice fragments, 10% volcanic lithics, 5% quartz and sanidine crystals.	**Qbo**	Note: Marked increase in pumice fragments.
740–745	Tuff, light gray (7.5YR7/1) to light brown (7.5YR6/4), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 5 mm), and crystals in an ashy matrix. +10F: 15% pumice fragments, 85% volcanic lithics. +35F: 60% pumice fragments, 30% volcanic lithics, 10% quartz and sanidine crystals.	**Qbo**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
745–755	Tuff, light gray (7.5YR7/1) to dark gray (7.5YR4/1), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 10 mm), and crystals in an ashy matrix. +10F: 2–5% pumice fragments, 95–98% volcanic lithics. +35F: 5–10% pumice fragments, 15–20% volcanic lithics, 65–75% quartz and sanidine crystals.	**Qbo**	
755–760	Tuff, light gray (7.5YR7/1) to pinkish gray (7.5YR6/2), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics, and crystals in an ashy matrix. +10F: 90% pumice fragments, 10% volcanic lithics. +35F: 45% pumice fragments, 25% volcanic lithics, 30% quartz and sanidine crystals.	**Qbo**	Note: Marked increase in pumice fragments.
760–780	Tuff, light gray (7.5YR7/1) to gray (7.5YR5/1), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 10 mm), and crystals in an ashy matrix. +10F: 20–35% pumice fragments, 65–80% volcanic lithics. +35F: 25–35% pumice fragments, 20–45% volcanic lithics, 35–45% quartz and sanidine crystals.	**Qbo**	
780–785	As above (760–780) with increase in pumice fragments in +10F: 70%.	**Qbo**	
785–830	Tuff, light gray (7.5YR7/1) to gray (7.5YR5/1), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 10 mm), and crystals in an ashy matrix. +10F: 30–45% pumice fragments, 55–70% volcanic lithics, trace quartz and sanidine crystals. +35F: 30–40% pumice fragments, 20–45% volcanic lithics, 30–40% quartz and sanidine crystals.	**Qbo**	
830–835	Tuff, light gray (7.5YR7/1) to gray (7.5YR5/1), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 5 mm), and crystals in an ashy matrix. +10F: 5% pumice fragments, 95% volcanic lithics. +35F: 10% pumice fragments, 25% volcanic lithics, 65% quartz and sanidine crystals.	**Qbo**	

Borehole Identification (ID): R-30	**Technical Area (TA):** 49	**Page:** 15 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
835–880	Tuff, light gray (7.5YR7/1) to gray (7.5YR5/1), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 8 mm), and crystals in an ashy matrix. +10F: 20–45% pumice fragments, 55–80% volcanic lithics. +35F: 30–40% pumice fragments, 20-45% volcanic lithics, 30–40% quartz and sanidine crystals.	**Qbo**	
835–880	Tuff, light gray (7.5YR7/1) to gray (7.5YR5/1), partly to nonwelded, light gray to light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 8 mm), and crystals in an ashy matrix. +10F: 20–45% pumice fragments, 55–80% volcanic lithics. +35F: 30–40% pumice fragments, 20–45% volcanic lithics, 30–40% quartz and sanidine crystals.	**Qbo**	
880–897	**GUAJE PUMICE BED OF THE OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, light gray (7.5YR7/1) to white (7.5YR8/1), white fibrous, vitric pumice lapilli fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 5 mm), and crystals. +10F: 60–80% pumice fragments, 20–40% volcanic lithics. +35F: 40–55% pumice fragments, 25–35% volcanic lithics, 10–25% quartz and sanidine crystals.	**Qbog**	Note: Contact between Qbo and Qbog at 880 ft bgs corresponds with minor shift on gamma log. Interval contains a marked appearance and increase in white fibrous, vitric pumice
897–915	**PUYE FORMATION:** Volcaniclastic sediments, light gray (5YR7/1) to pale red (2.5YR6/2), moderately sorted, well graded with medium to very coarse sand-size fragments (GW), grains subangular to subrounded (up to 12 mm). +10F: 95–98% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 2–5% pumice fragments. +35F: 65–70% volcanic lithics, 20–25% pumice fragments, 5–10% quartz and sanidine crystals.	**Tpf**	Note: Contact between Qbog and Tpf at 897 ft bgs corresponds with a significant shift on gamma log and video log. At 900 ft bgs, a significant change occurs in color, clast size (up to 15–20 mm), and composition (loss of pumice).

Borehole Identification (ID): R-30	**Technical Area (TA):** 49	**Page:** 13 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
915–1035	Volcaniclastic sediments, light gray (5YR7/1) to dark reddish gray (2.5YR4/1), moderately to poorly sorted, moderately to well graded with medium to very coarse sand-size fragments (GW), grains subangular to subrounded (up to 5–10 mm). +10F: 97–100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), trace–3%pumice fragments. Trace tuffaceous siltstone/sandstone. +35F: 90–97% volcanic lithics, 2–7% pumice fragments, trace–3% quartz and sanidine crystals.	**Tpf**	
1035–1040	Volcaniclastic sediments, light gray (7.5YR7/1) to light reddish brown (5YR6/4), moderately to well sorted, poorly graded with fine to medium sand sized fragments (GM), grains subangular to subrounded (up to 3 mm). +10F: 60% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 40% pumice fragments. Minor tuffaceous sandstone. +35F: 50% volcanic lithics, 35% pumice fragments, 15% quartz and sanidine crystals.	**Tpf**	Note: Marked increase in pumice fragments in this interval.
1040–1070	Volcaniclastic sediments, light gray (5YR7/1) to dark reddish gray (2.5YR4/1), moderately to poorly sorted, moderately to well graded with medium to very coarse sand size fragments (GW), grains subangular to subrounded (up to 5–12 mm). +10F: 97–100% aphanitic to porphyritic intermediate-mafic composition volcanic lithics (including dacite and trace vesicular basalt/basaltic andesite), trace–3% pumice fragments. Trace tuffaceous siltstone/sandstone. +35F: 90–94% volcanic lithics, 2–10% pumice fragments, trace–3% quartz and sanidine crystals.	**Tpf**	
1070–1090	Volcaniclastic sediments, light gray (5YR7/1) to dark reddish gray (2.5YR4/1), moderately to poorly sorted, moderately to well graded with medium to very coarse sand-size fragments (GW), grains subangular to subrounded (up to 5–12 mm). +10F: 97–100% aphanitic to porphyritic intermediate-mafic composition volcanic lithics (including vesicular/scoriaceous basalt/basaltic andesite and lesser dacite), trace–3% pumice fragments. Trace tuffaceous siltstone/sandstone. +35F: 90–94% volcanic lithics, 2–10% pumice fragments, trace–3% quartz and sanidine crystals.	Tpf	Note: Marked increase in basalt / basaltic-andesite content to as much as 15% in 1085–1090-ft-bgs interval.

Borehole Identification (ID): R-30	**Technical Area (TA):** 49	**Page:** 17 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
1070–1090	Volcaniclastic sediments, light gray (5YR7/1) to dark reddish gray (2.5YR4/1), moderately to poorly sorted, moderately to well graded with medium to very coarse sand-size fragments (GW), grains subangular to subrounded (up to 5–12 mm). +10F: 97–100% aphanitic to porphyritic intermediate-mafic composition volcanic lithics (including vesicular/scoriaceous basalt/basaltic andesite and lesser dacite), trace–3% pumice fragments. Trace tuffaceous siltstone/sandstone. +35F: 90–94% volcanic lithics, 2–10% pumice fragments, trace–3% quartz and sanidine crystals.	Tpf	Note: Marked increase in basalt/basaltic-andesite content to as much as 15% in 1085–1090-ft-bgs interval.
1090–1110	**CERROS DEL RIO VOLCANIC ROCKS:** Aphanitic to porphyritic, nonvesiculated to moderately vesicular scoriaceous intermediate lava containing notable phenocrysts of plagioclase feldspar and clinopyroxene and trace quartz and olivine, both with reaction rims, gray (10YR6/1) to very dark gray (10YR3/1). +10F: 100% intermediate-mafic lavas. +35F: 100% intermediate-mafic lavas. Reddish-brown oxidation on fragments. Epidote present as an alteration mineral.	**Tb_4**	Note: Contact between Tpf and Tb 4 at 1090 ft bgs corresponds with a minor shift on gamma log and change in cuttings lithology. There is a significant change in lithology to 100% intermediate-mafic lava in cuttings.
1110–1125	**PUYE FORMATION:** Volcaniclastic sediments, light gray (5YR7/1) to very dark gray (10YR3/1), poorly to moderately sorted, well graded with fine coarse sand-size fragments(GW), grains subangular to subrounded (up to 10 mm). +10F: 100% aphanitic to porphyritic intermediate-mafic composition volcanic lithics and scoria (including dacite), moderately to strongly vesicular, with amygdaloidal structure, in filled vesicles. +35F: 98% volcanic lithics, 2% pumice fragments, trace quartz and sanidine crystals. Red to red-brown oxidation on most fragments.	**Tpf**	Note: Contact between Tb 4 and Tpf at 1110 ft bgs corresponds with a minor shift on gamma log and change in cuttings lithology.

Borehole Identification (ID): R-30	**Technical Area (TA):** 49	**Page:** 18 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 03/15/10 1945	**End Date/Time:** 03/24/10 1115
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7073.14		**Total Depth:** 1196 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires, A. Feltman	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
1125–1155	Volcaniclastic sediments, light gray (5YR7/1) to dark reddish gray (2.5YR4/1), moderately to poorly sorted, moderately to well graded with fine to very coarse sand size fragments (GW), grains subangular to subrounded (up to 5–12 mm). +10F: 96–100% aphanitic to porphyritic intermediate-mafic composition volcanic lithics and lesser scoria (including dacite and vesicular basalt/basaltic andesite), trace–4% pumice fragments. Minor tuffaceous siltstone/sandstone. Trace quartz crystals (including rose quartz). +35F: 90–94% volcanic lithics, 2–10% pumice fragments, trace–3% quartz and sanidine crystals.	**Tpf**	
1155–1195	Volcaniclastic sediments, light gray (5YR7/1) to reddish gray (2.5YR5/1), moderately to poorly sorted, moderately to well graded with fine to very coarse sand-size fragments (GW), grains subangular to subrounded (up to 15–20 mm). +10F: 96-100% aphanitic to porphyritic intermediate-mafic composition volcanic lithics (including dacite), trace–4% pumice fragments. +35F: 90–94% volcanic lithics, 2–10% pumice fragments, trace–3% quartz and sanidine crystals.	**Tpf**	Bottom of borehole at 1196 ft bgs.

Abbreviations

7.5YR8/1 = Munsell soil color notation where hue, value, and chroma are expressed (e.g., hue=10YR, value=6, and chroma=3)

35% crystals = percentage of material in sieve sample fraction

bgs = below ground surface

ft = foot

GW = well graded

GM = silty graded

Qal = Quaternary alluvium

Qbt 4 = Unit 4 of the Tshirege Member of the Bandelier Tuff

Qbt 3 = Unit 2 of the Tshirege Member of the Bandelier Tuff

Qbt 2 = Unit 2 of the Tshirege Member of the Bandelier Tuff

Qbt 1v = Unit 1v of the Tshirege Member of the Bandelier Tuff

Qbt 1g = Unit 1g of the Tshirege Member of the Bandelier Tuff

Qct = Cerro Toledo interval

Qbo = Otowi Member of the Bandelier Tuff

Qbog = Guaje Pumice Bed of the Otowi Member of the Bandelier Tuf

Tb 4 = Cerros del Rio volcanic rocks

Tpf = Puye Formation

WR = whole rock

+10F = plus No. 10 sieve sample fraction

+35F = plus No. 35 sieve sample fraction

Appendix B

Groundwater Analytical Results

B-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-30

A total of five groundwater-screening samples were collected during drilling and development at well R-30. Two groundwater-screening samples were collected during drilling at 1138 and 1195 ft below ground surface (bgs) (GW30-10-14925 and GW30-10-14926, respectively) from the regional aquifer within the Puye Formation. Aliquots of these samples were submitted to the Los Alamos National Laboratory (LANL or the Laboratory) Earth and Environmental Sciences Group 14 (EES-14) laboratory for metals, cations and anions (including perchlorate) analyses; aliquots were also submitted to an offsite analytical laboratory for analyses of volatile organic compounds (VOCs), high explosive (HE) compounds and low-level tritium (LH3).

Three groundwater-screening samples (GW30-10-14920, GW30-10-14921, and GW30-10-14929) were collected from the completed well during development from approximately 1160 ft bgs. Aliquots of these samples were analyzed by EES-14 for metals, cations and anions (including perchlorate) and total organic carbon (TOC).

B-1.1 EES-14 Analytical Techniques

Chemical analyses of groundwater-screening samples were performed at. Groundwater samples were filtered (0.45-µm membranes) before preservation and chemical analyses. Samples were acidified at the EES-14 wet chemistry laboratory with analytical grade nitric acid to a pH of 2.0 or less for metal and major cation analyses.

Groundwater-screening samples were analyzed using techniques specified by the U.S. Environmental Protection Agency (EPA) methods for water analyses. Ion chromatography (EPA Method 300, Revision 2.1) was the analytical method for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. The instrument detection limits for perchlorate were 0.002 and 0.005 ppm (EPA Method 314.0 Revision 1). Inductively coupled (argon) plasma optical emission spectroscopy (EPA Method 200.7, Revision 4.4) was used for analyses of dissolved aluminum, barium, boron, calcium, total chromium, iron, lithium, magnesium, manganese, potassium, silica, sodium, strontium, titanium, and zinc. Dissolved aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (EPA Method 200.8, Revision 5.4). The precision limits (analytical error) for major ions and trace elements were generally less than ±7%.

Total carbonate alkalinity (EPA Method 310.1) was measured using standard titration techniques. Charge balance errors for total cations and anions for the groundwater-screening samples ranged from -4% to -10%. The negative cation-anion charge balance values indicate excess anions for the filtered samples. Analyses of TOC were performed on groundwater-screening samples collected during development in accordance with EPA Method 415.1. No groundwater samples were collected for TOC analyses at borehole R-30 before development because of potential sample matrix influence from the presence of drilling fluids.

B-1.2 Field Parameters

B-1.2.1 Well Development

Water samples were drawn from the pump discharge line into sealed containers, and field parameters were measured using a YSI multimeter. Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, and turbidity measured during development at well R-30, are provided in Table B-1.2-1.

The pH measurements during development varied from 7.7 to 12.3; the large variation indicates the meter was malfunctioning. Temperature varied from 11.3 to 20.0°C, DO varied from 1.3 to 3.9 mg/L, and specific conductance ranged from 113 to 263 microsiemens per centimeter (µS/cm). Corrected oxidation-reduction potential (Eh) values ranged from 182.1 mV to 297.0 mV during well development. Corrected Eh values associated with well R-30 are considered to be generally reliable and representative of the known relatively oxidizing conditions characteristic of the regional aquifer beneath the Pajarito Plateau.

Two turbidity readings of 1776 and 1886 NTU were measured at the beginning of well development during the swabbing and bailing phase. Turbidity values ranged from 0.0 to 3.1 NTU over the course of development when a submersible pump was used. The majority of readings recorded during pumping were 0.0 NTU, indicating the meter was malfunctioning. Final accurate parameter measurements at the end of development were temperature of 19.0°C and specific conductance of 122 µS/cm. Table B-1.2-1 presents field parameters and discharge volumes recorded during development.

B-1.3 Analytical Results for Groundwater-Screening Samples

Analytical results from the off-site laboratory and from EES-14 are presented in Tables B-1.3-1 and B-1.3-2, respectively, and are discussed below. Where available, analytical results for well R-30 collected only during well development are screened against background concentrations developed for the Laboratory as a whole (LANL 2007, 095817). It should be noted that, because of localized variations in geochemistry, background concentrations for the area upgradient of well R-30 may vary.

B-1.3.1 Volatile Organic Compounds, High Explosive Compounds, and Low-Level Tritium

Two borehole samples collected during drilling of R-30 (GW30-10-14925 and GW30-10-14926 from 1138 and 1195 ft bgs, respectively) were analyzed for VOCs, HE, and LH3 (Table B-1.3-1). Additionally, two blank samples were submitted for analysis of VOCs (GW30-10-14927 and GW30-10-14928).

One VOC, carbon disulfide, was reported at an estimated concentration of 0.35 µg/L (less than the 1 µg/L detection limit) in borehole sample GW30-10-14925 from 1138 ft bgs. No VOCs were detected in borehole sample GW30-10-14926 from 1195 ft bgs.

Three VOCs were reported at estimated concentrations in the two trip blanks. Acetone and vinyl chloride were reported at 1.3 and 0.077 µg/L, respectively, in blank sample GW30-10-14927. Acetone was also reported at 1.3 µg/L in blank sample GW30-10-14928.

No high explosive compounds were detected in the borehole water samples collected from R-30. Tritium was detected at a concentration of 0.79 tritium units (2.54 pCi/L) in sample GW30-10-14925 from 1138 ft bgs and was not detected in sample GW30-10-14926 from 1195 ft bgs (Table B-1.3-1).

B-1.3.2 Cations, Anions, Perchlorate, and Metals

EES-14 analytical results for the two borehole samples collected during drilling and the three samples collected during well development are provided in Table B-1.3-2.

Borehole samples GW30-10-14925 and GW30-10-14926 consisted of colloidal aquifer material, drilling material, water used during drilling, and native regional groundwater.

The following anions were detected from the screening samples from R-30:

- Dissolved concentrations of fluoride were 0.86 and 0.48 ppm in the two borehole water samples; fluoride concentrations in the developed well samples ranged from 0.23 to 0.25 ppm. For comparison purposes, the median background concentration of dissolved fluoride is 0.35 mg/L from developed wells in the regional aquifer (LANL 2007, 095817).
- Dissolved concentrations of nitrate(N) were 0.19 and 0.24 ppm in the two borehole water samples, whereas nitrate(N) concentrations in the developed well ranged from 0.34 to 0.35 ppm. The median background concentration for dissolved nitrate(N) in the regional aquifer is 0.31 ppm.
- Dissolved concentrations of sulfate were 3.83 and 2.85 ppm in the borehole water samples but decreased to between 2.08 and 2.55 ppm during development. The median background concentration for sulfate in the regional aquifer is 2.83 ppm (LANL 2007, 095817).
- Perchlorate was not detected in the two borehole water samples (<0.005 ppm) or the three well development samples (<0.002 ppm).

The following metals were detected from the screening samples collected at R-30. A corroded carbon-steel discharge pipe was used during development at well R-30, resulting in elevated concentrations of colloidal iron, manganese, and zinc.

- During development, dissolved concentrations of iron varied from 0.23 to 0.33 ppm. The median background concentration for dissolved iron in the regional aquifer is 0.01885 mg/L (LANL 2007, 095817).
- Dissolved concentrations of manganese measured during development varied from 0.045 to 0.035 ppm. The median background concentration for dissolved manganese in the regional aquifer is 0.001 mg/L (LANL 2007, 095817).
- During development, dissolved concentrations of zinc varied from 0.062 to 0.050 ppm. The median background concentration for dissolved zinc in the regional aquifer is 0.00145 mg/L (LANL 2007, 095817).
- Dissolved molybdenum was reported at 0.072 ppm in GW30-10-14925 from 1138 ft bgs, indicating the presence of drilling lubricant in that sample. The three groundwater-screening samples (GW30-10-14920, GW30-10-14921, and GW30-10-14929) collected during development contained 0.001 ppm (0.001 mg/L) of dissolved molybdenum, which is at the method detection limit for this analyte using inductively couple plasma-mass spectrometry.
- Dissolved concentrations of boron were 0.156 and 0.306 ppm in the two borehole water samples collected during drilling of R-30. During development, boron decreased from 0.039 to 0.035 ppm. The maximum background concentration for dissolved boron in the regional aquifer is 0.0516 ppm (LANL 2007, 095817).
- Dissolved concentrations of barium were 1.204 and 2.122 ppm in the two borehole water samples collected during drilling of R-30. Dissolved concentrations of barium varied from 0.247 to 0.375 ppm during development. The maximum background concentration for dissolved barium in the regional aquifer is 1.15 ppm (LANL 2007, 095817).
- Concentrations of total dissolved chromium were 0.002 and 0.003 ppm in the two borehole water samples. During development of well R-30, dissolved chromium was also reported 0.002 and 0.003 ppm. Background median and maximum concentrations of total dissolved chromium are 0.00305 and 0.00720 ppm, respectively, for the regional aquifer (LANL 2007, 095817).

B-1.3.3 Total Organic Carbon

Concentrations of TOC were 0.23, 0.28 and 0.18 mgC/L in three samples collected during well development. These values are below the 2 mgC/L target TOC concentration at the end of well development. The median background concentration of TOC is 0.34 mgC/L for regional aquifer groundwater (LANL 2007, 095817).

B-1.4 Summary

In summary, groundwater at well R-30 is relatively oxidizing based on both positive Eh values and measurable concentrations of DO recorded during well development and aquifer testing. Carbon disulfide (0.35 μg/L) and tritium (2.54 pCi/L) were reported in borehole sample GW30-10-14925 from 1138 ft bgs, but were not detected in the second borehole sample from 1195 ft bgs. HE compounds and perchlorate were not detected in either borehole screening sample. TOC was below the target concentration of 2 mgC/L at the end of well development.

B-2.0 REFERENCE

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), May 2007. "Groundwater Background Investigation Report, Revision 3," Los Alamos National Laboratory document LA-UR-07-2853, Los Alamos, New Mexico. (LANL 2007, 095817)

Table B-1.2-1
Purge Volumes during Well Development and Aquifer Testing and Water-Quality Parameters for R-30

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development–Swabbing/Bailing									
04/07/10	0900	10.1	11.3	3.9	n/r[b]	261	1776.0	0	0
	1611	n/r	n/r	n/r	n/r	n/a	n/a	160	160
04/08/10	1000	8.1	11.5	2.2	n/r	263	1886.0	80	240
Well Development									
04/09/10	1045	8.0	18.9	1.8	84.2, 288.1	129	0.0	1300	1540
	1145	7.9	19.1	1.3	93.1, 297.0	127	0.0	512	2052
	1245	9.3	19.4	1.5	78.0, 281.9	124	0.0	312	2364
	1345	7.7	19.3	1.4	59.4, 263.3	124	0.0	557	2921
	1430	7.7	18.2	1.7	51.5, 255.4	126	0.0	391	3312
	1530	8.2	19.6	1.9	34.5, 238.4	123	0.0	501	3813
	1630	8.4	19.6	1.9	26.9, 230.8	123	0.0	471	4284
	1700	8.4	19.6	1.9	26.7, 230.6	123	0.0	151	4435
04/10/10	0800	11.8	18.0	1.3	-21.8, 182.1	125	3.1	236	4671
	0830	11.2	18.2	1.5	-5.0, 198.9	123	2.6	239	4910
	0900	11.4	18.7	1.7	-10.0, 193.9	121	1.7	232	5142
	0930	10.5	19.1	2.9	18.5, 222.4	122	1.0	219	5361
	1000	10.7	18.7	2.4	15.2, 219.1	121	0.4	228	5589
	1030	10.3	18.7	2.2	2.8, 206.7	122	0.0	262	5851
	1100	10.1	19.2	2.0	28.0, 231.9	121	0.0	253	6104
	1130	10.0	19.4	2.0	16.3, 220.2	121	0.1	236	6340
	1200	10.0	19.4	2.1	34.4, 238.3	121	0.3	231	6571
	1230	9.7	19.7	1.9	40.8, 244.7	124	0.0	322	6893
	1300	9.7	19.6	1.9	48.0, 251.9	120	0.0	168	7061
	1330	9.5	19.8	1.8	35.8, 239.7	121	0.0	260	7321
	1400	9.6	19.9	1.9	5.5, 209.4	122	0.0	232	7553
	1430	9.4	19.7	1.8	2.5, 206.4	122	0.0	265	7818
	1500	9.5	20.0	1.8	24.8, 228.7	122	0.0	206	8024
	1530	9.4	20.0	3.0	20.8, 224.7	121	0.0	244	8268
	1600	9.4	19.8	2.3	22.1, 226.0	121	0.0	248	8516
	1630	9.4	19.9	1.9	21.9, 225.8	122	0.0	258	8774
	1700	9.4	20.0	2.1	16.9, 220.8	123	0.0	212	8986
	1730	9.4	19.7	1.9	18.1, 222.0	113	0.0	262	9248
	1800	9.5	19.6	1.8	2.1, 206.0	123	0.0	225	9473
	1830	9.6	19.1	1.8	16.1, 220.0	123	0.0	215	9688

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
04/11/10	0800	12.3	18.2	2.0	22.1, 226.0	123	0.0	238	9926
	0830	11.9	18.6	1.6	4.4, 208.3	123	0.0	241	10,167
	0900	11.3	18.6	1.9	20.9, 224.8	123	2.8	280	10,447
	0930	11.2	18.7	1.9	28.8, 232.7	122	0.9	311	10,758
	1000	11.1	18.9	2.1	35.2, 239.1	121	0.0	316	11,074
	1030	10.9	19.0	1.9	37.2, 241.1	122	0.0	302	11,376
Aquifer Testing									
04/12/10	0920	9.2	17.4	0.8	-6.9, 197.0	125	5.1	79	11,455
	0936	9.5	18.4	1.0	-22.3, 181.6	119	1.8	105	11,560
	1100	9.1	19.8	0.7	-0.5, 203.4	122	0.8	20	11,580
	1130	9.2	19.8	0.9	2.7, 206.6	121	1.4	185	11,765
	1200	9.5	19.3	1.3	0.7, 204.6	119	0.0	225	11,990
04/14/10	1000	5.8	14.4	1.5	13.9, 217.8	116	87.1	----	11,990
	1030	5.9	19.1	6.6	39.1, 243.0	129	6.0	194	12,184
	1100	6.7	20.1	7.9	80.3, 284.2	93	1.9	194	12,378
	1130	6.8	20.1	7.8	43.4, 247.3	95	0.5	195	12,573
	1200	6.7	20.7	6.8	57.1, 261.0	89	1.1	194	12,767
	1230	5.5	20.4	5.7	79.7, 283.6	102	0.5	195	12,962
	1300	5.6	20.6	5.6	73.5, 277.4	109	1.1	195	13,157
	1330	6.1	20.5	5.4	67.7, 271.6	105	1.2	195	13,352
	1400	6.0	20.3	5.2	70.1, 274.0	100	0.6	195	13,547
	1430	6.1	20.1	5.3	63.5, 267.4	101	1.7	195	13,742
	1500	6.2	20.4	4.6	53.3, 257.2	98	0.4	195	13,937
	1530	6.1	20.3	4.8	57.7, 261.6	99	0.4	195	14,132
	1600	6.3	20.2	4.4	46.3, 250.2	100	0.3	195	14,327
	1630	6.3	20.4	4.2	37.4, 241.3	97	1.1	195	14,522
	1700	6.5	20.3	4.0	37.0, 240.9	92	2.7	195	14,717
	1730	6.4	20.0	3.9	33.5, 237.4	105	1.0	195	14,912
	1800	6.5	20.0	3.8	33.3, 237.2	100	0.1	195	15,107
	1830	6.6	10.8	3.6	25.3, 239.1	101	0.7	195	15,302
	1900	6.8	19.2	5.0	13.6, 217.5	93	0.0	179	15,481
	1930	7.2	18.9	4.6	19.3, 223.2	90	0.0	195	15,676
	2000	8.4	19.1	3.3	-0.9, 203.0	84	0.0	203	15,879
	2030	8.8	19.0	3.8	46.5, 250.4	84	0.0	203	16,082
	2100	9.2	19.1	3.8	1.2, 205.1	84	0.0	189	16,271
	2130	9.5	19.0	3.7	-30.1, 173.8	84	0.0	192	16,463

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
04/14/10	2200	9.7	18.4	3.8	-36.6, 167.3	84	0.0	192	16,655
	2230	8.9	18.7	3.4	-35.7, 168.2	84	0.0	196	16,851
	2300	8.7	18.7	3.7	-37.6, 166.3	85	0.0	189	17,040
	2330	8.9	18.8	3.7	-24.3, 179.6	85	0.0	199	17,239
04/15/10	0000	9.0	19.2	3.5	-37.1, 166.8	85	0.0	196	17,435
	0030	9.1	18.9	3.4	-36.7, 167.2	85	0.0	195	17,630
	0100	8.9	18.9	3.5	-36.7, 167.2	85	0.0	192	17,822
	0130	9.1	18.8	3.3	-35.2, 168.7	85	0.0	195	18,017
	0200	9.2	19.0	3.2	-36.7, 167.2	85	0.0	193	18,210
	0230	9.2	19.0	3.3	-37.5, 166.4	85	0.0	197	18,407
	0300	9.3	19.0	3.3	-37.5, 166.4	85	0.0	196	18,603
	0330	9.3	18.9	3.0	-35.8, 168.1	83	0.0	190	18,793
	0400	9.4	18.9	3.0	-36.7, 167.2	85	0.0	193	18,986
	0430	9.4	19.2	2.7	-36.4, 167.5	85	0.0	196	19,182
	0500	9.4	19.1	2.8	-37.3, 166.6	85	0.0	191	19,373
	0530	9.3	19.0	2.9	-36.8, 167.1	85	0.0	194	19,567
	0600	9.4	18.9	2.7	-36.9, 167.0	85	0.0	195	19,762
	0630	9.4	19.0	2.6	-36.5, 167.4	85	0.0	192	19,954
	0700	9.3	18.9	2.6	-36.9, 167.0	85	0.0	193	20,147
	0730	9.4	19.3	2.1	-42.0, 161.9	85	0.0	193	20,340
	0800	9.5	19.4	2.2	-37.8, 166.1	85	0.9	192	20,532
	0830	9.6	19.4	2.1	-38.9, 165.0	85	0.0	192	20,724
	0900	9.7	19.4	2.0	-35.5, 168.4	85	0.0	193	20,917
	0930	9.5	19.6	1.7	-36.6, 167.3	85	0.0	193	21,110
	1000	9.7	19.6	2.2	-39.4, 164.5	85	0.0	193	21,303

[a] Eh (mV) is calculated from a Ag/AgCl-saturated KCl electrode filling solution at 20ºC by adding a temperature-sensitive correction factor of 203.9 mV.

[b] n/r = Not recorded.

Table B-1.3-1
Off-Site Laboratory Analytical Results

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2647	GW30-10-14925	LH3	Generic:Low_Level_Tritium	Tritium	0.79	TU[a]	NQ[b]
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	2,4-Diamino-6-nitrotoluene	0.05	µg/L	U[c]
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	2,6-Diamino-4-nitrotoluene	0.05	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	3,5-Dinitroaniline	0.05	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Amino-2,6-dinitrotoluene[4-]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Amino-4,6-dinitrotoluene[2-]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Dinitrobenzene[1,3-]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Dinitrotoluene[2,4-]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Dinitrotoluene[2,6-]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	HMX[d]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Nitrobenzene	0.25	µg/L	UJ[e]
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Nitrotoluene[2-]	0.5	µg/L	UJ
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Nitrotoluene[3-]	1	µg/L	UJ
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Nitrotoluene[4-]	0.5	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	PETN[f]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	RDX[g]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	TATB[h]	1	µg/L	UJ
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Tetryl	0.2	µg/L	UJ
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Trinitrobenzene[1,3,5-]	0.2	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Trinitrotoluene[2,4,6-]	0.1	µg/L	U
10-2589	GW30-10-14925	HE	SW-846:8321A_MOD	Tris (o-cresyl) phosphate	0.05	µg/L	UJ
10-2600	GW30-10-14925	METALS	SW-846:6020	Aluminum	281000	µg/L	J+[i]
10-2600	GW30-10-14925	METALS	SW-846:6020	Antimony	10	µg/L	UJ

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14925	METALS	SW-846:6020	Arsenic	26.8	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Barium	5040	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Beryllium	10.7	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Boron	43.6	µg/L	J[j]
10-2600	GW30-10-14925	METALS	SW-846:6020	Cadmium	1.3	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Calcium	154000	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Chromium	467	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Cobalt	232	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Copper	392	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Iron	776000	µg/L	J+
10-2600	GW30-10-14925	METALS	SW-846:6020	Lead	115	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Magnesium	96500	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Manganese	9600	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:7470A	Mercury	0.094	µg/L	J
10-2600	GW30-10-14925	METALS	SW-846:6020	Nickel	596	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Potassium	42500	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Selenium	12	µg/L	J-[k]
10-2600	GW30-10-14925	METALS	SW-846:6020	Silver	0.66	µg/L	J
10-2600	GW30-10-14925	METALS	SW-846:6020	Sodium	68800	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Strontium	2850	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Thallium	2	µg/L	U
10-2600	GW30-10-14925	METALS	SW-846:6020	Tin	8.7	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Uranium	19.2	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Vanadium	488	µg/L	NQ
10-2600	GW30-10-14925	METALS	SW-846:6020	Zinc	2800	µg/L	NQ

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2589	GW30-10-14925	VOC	SW-846:8260B	Acetone	6.1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Acetonitrile	25	µg/L	R[I]
10-2589	GW30-10-14925	VOC	SW-846:8260B	Acrolein	5	µg/L	R
10-2589	GW30-10-14925	VOC	SW-846:8260B	Acrylonitrile	5	µg/L	R
10-2589	GW30-10-14925	VOC	SW-846:8260B	Benzene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Bromobenzene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Bromoform	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Bromomethane	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Butanol[1-]	40	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Butanone[2-]	5	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Carbon Disulfide	0.35	µg/L	J
10-2589	GW30-10-14925	VOC	SW-846:8260B	Carbon Tetrachloride	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chloroethane	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chloroform	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chloromethane	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dibromomethane	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichlorodifluoromethane	1	µg/L	UJ
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Diethyl Ether	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Ethyl Methacrylate	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Hexachlorobutadiene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Iodomethane	5	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Isobutyl alcohol	50	µg/L	R
10-2589	GW30-10-14925	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2589	GW30-10-14925	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Methacrylonitrile	5	µg/L	UJ
10-2589	GW30-10-14925	VOC	SW-846:8260B	Methyl Methacrylate	1	µg/L	R
10-2589	GW30-10-14925	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Methylene Chloride	1	µg/L	UJ
10-2589	GW30-10-14925	VOC	SW-846:8260B	Naphthalene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Propionitrile	5	µg/L	R
10-2589	GW30-10-14925	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Styrene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Toluene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichloroethene	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichlorofluoromethane	1	µg/L	UJ
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Vinyl acetate	5	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Vinyl Chloride	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2589	GW30-10-14925	VOC	SW-846:8260B	Xylene (Total)	2	µg/L	U
10-2589	GW30-10-14925	VOC	SW-846:8260B	Xylene[1,2-]	1	µg/L	U
10-2647	GW30-10-14926	LH3	Generic:Low_Level_Tritium	Tritium	0.14	TU	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	2,4-Diamino-6-nitrotoluene	0.05	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	2,6-Diamino-4-nitrotoluene	0.05	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	3,5-Dinitroaniline	0.05	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Amino-2,6-dinitrotoluene[4-]	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Amino-4,6-dinitrotoluene[2-]	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Dinitrobenzene[1,3-]	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Dinitrotoluene[2,4-]	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Dinitrotoluene[2,6-]	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	HMX[i]	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Nitrobenzene	0.25	µg/L	UJ
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Nitroglycerin	1	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Nitrotoluene[2-]	0.5	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Nitrotoluene[3-]	1	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Nitrotoluene[4-]	0.5	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	PETN	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	RDX	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	TATB[j]	1	µg/L	UJ
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Tetryl	0.2	µg/L	UJ
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Trinitrobenzene[1,3,5-]	0.2	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Trinitrotoluene[2,4,6-]	0.1	µg/L	U
10-2600	GW30-10-14926	HE	SW-846:8321A_MOD	Tris (o-cresyl) phosphate	0.05	µg/L	UJ
10-2600	GW30-10-14926	METALS	SW-846:6020	Aluminum	60700	µg/L	J+
10-2600	GW30-10-14926	METALS	SW-846:6020	Antimony	10	µg/L	UJ

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14926	METALS	SW-846:6020	Arsenic	4.4	µg/L	J
10-2600	GW30-10-14926	METALS	SW-846:6020	Barium	671	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Beryllium	2.2	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Boron	100	µg/L	U
10-2600	GW30-10-14926	METALS	SW-846:6020	Cadmium	1	µg/L	U
10-2600	GW30-10-14926	METALS	SW-846:6020	Calcium	22400	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Chromium	29.8	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Cobalt	31	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Copper	87.8	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Iron	109000	µg/L	J+
10-2600	GW30-10-14926	METALS	SW-846:6020	Lead	25.6	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Magnesium	12900	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Manganese	1610	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:7470A	Mercury	0.2	µg/L	U
10-2600	GW30-10-14926	METALS	SW-846:6020	Nickel	69.4	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Potassium	10400	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Selenium	1.8	µg/L	J-
10-2600	GW30-10-14926	METALS	SW-846:6020	Silver	4	µg/L	U
10-2600	GW30-10-14926	METALS	SW-846:6020	Sodium	18800	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Strontium	273	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Thallium	4	µg/L	U
10-2600	GW30-10-14926	METALS	SW-846:6020	Tin	2.2	µg/L	J
10-2600	GW30-10-14926	METALS	SW-846:6020	Uranium	3.8	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Vanadium	39	µg/L	NQ
10-2600	GW30-10-14926	METALS	SW-846:6020	Zinc	391	µg/L	NQ
10-2600	GW30-10-14926	VOC	SW-846:8260B	Acetone	2.2	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14926	VOC	SW-846:8260B	Benzene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Bromobenzene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Bromoform	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Bromomethane	2	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Butanone[2-]	5	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Carbon Disulfide	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Carbon Tetrachloride	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Chloroethane	2	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Chloroform	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Chloromethane	2	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dibromomethane	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichlorodifluoromethane	2	µg/L	UJ

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloroethene[cis/trans-1,2-]	2	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Iodomethane	2	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Methyl tert-Butyl Ether	2	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Methylene Chloride	1	µg/L	UJ
10-2600	GW30-10-14926	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Styrene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Toluene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trichloroethene	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trichlorofluoromethane	2	µg/L	UJ
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Vinyl Chloride	2	µg/L	U
10-2600	GW30-10-14926	VOC	SW-846:8260B	Xylene (Total)	3	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Acetone	1.3	µg/L	J
10-2589	GW30-10-14927	VOC	SW-846:8260B	Acetonitrile	25	µg/L	R
10-2589	GW30-10-14927	VOC	SW-846:8260B	Acrolein	5	µg/L	R
10-2589	GW30-10-14927	VOC	SW-846:8260B	Acrylonitrile	5	µg/L	R
10-2589	GW30-10-14927	VOC	SW-846:8260B	Benzene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Bromobenzene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Bromoform	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Bromomethane	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Butanol[1-]	40	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Butanone[2-]	5	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Carbon Disulfide	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Carbon Tetrachloride	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chloroethane	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chloroform	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chloromethane	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dibromomethane	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichlorodifluoromethane	1	µg/L	UJ
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2589	GW30-10-14927	VOC	SW-846:8260B	Diethyl Ether	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Ethyl Methacrylate	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Hexachlorobutadiene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Iodomethane	5	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Isobutyl alcohol	50	µg/L	R
10-2589	GW30-10-14927	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Methacrylonitrile	5	µg/L	UJ
10-2589	GW30-10-14927	VOC	SW-846:8260B	Methyl Methacrylate	1	µg/L	R
10-2589	GW30-10-14927	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Methylene Chloride	1	µg/L	UJ
10-2589	GW30-10-14927	VOC	SW-846:8260B	Naphthalene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Propionitrile	5	µg/L	R
10-2589	GW30-10-14927	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Styrene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Toluene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichloroethene	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichlorofluoromethane	1	µg/L	UJ
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Vinyl acetate	5	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Vinyl Chloride	0.077	µg/L	J
10-2589	GW30-10-14927	VOC	SW-846:8260B	Xylene (Total)	2	µg/L	U
10-2589	GW30-10-14927	VOC	SW-846:8260B	Xylene[1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Acetone	1.3	µg/L	J
10-2600	GW30-10-14928	VOC	SW-846:8260B	Benzene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Bromobenzene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Bromoform	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Bromomethane	2	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Butanone[2-]	5	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Carbon Disulfide	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Carbon Tetrachloride	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Chloroethane	2	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14928	VOC	SW-846:8260B	Chloroform	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Chloromethane	2	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dibromomethane	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichlorodifluoromethane	2	µg/L	UJ
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloroethene[cis/trans-1,2-]	2	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Iodomethane	2	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14928	VOC	SW-846:8260B	Methyl tert-Butyl Ether	2	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Methylene Chloride	1	µg/L	UJ
10-2600	GW30-10-14928	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Styrene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Toluene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trichloroethene	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trichlorofluoromethane	2	µg/L	UJ
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample Name	Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2600	GW30-10-14928	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Vinyl Chloride	2	µg/L	U
10-2600	GW30-10-14928	VOC	SW-846:8260B	Xylene (Total)	3	µg/L	U

[a] TU = Tritium unit.

[b] NQ = Data are valid and not qualified.

[c] U = The analyte was analyzed for but not detected.

[d] HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.

[e] UJ = The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit.

[f] PETN = Pentaerythritol tetranitrate.

[g] RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

[h] TATB = Triaminotrinitrobenzene.

[i] J + = The analyte was positively identified, and the result is likely to be biased high.

[j] J = The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis.

[k] J- = The analyte was positively identified, and the result is likely to be biased low.

[l] R = The data are rejected as a result of major problems with quality assurance/quality control parameters.

Table B-1.3-2
EES-14 Analytical Results

Sample ID	Date Received	Sample Type	ER/RRES-WQH	Depth (feet)	Ag rslt (ppm)	stdev (Ag)	Al rslt (ppm)	stdev (Al)	As rslt (ppm)	stdev (As)	B rslt (ppm)	stdev (B)	Ba rslt (ppm)	stdev (Ba)	Be rslt (ppm)	stdev (Be)	Br(-) ppm	TOC rslt (ppm)	Ca rslt (ppm)	stdev (Ca)	Cd rslt (ppm)	stdev (Cd)	Cl(-) ppm	ClO4(-) ppm
GW30-10-14925	3/31/2010	Borehole	10-2008	1138	0.001	U*	0.174	0.002	0.0008	0.0001	0.306	0.002	2.122	0.009	0.001	U	0.03	Not analyzed	6.74	0.03	0.001	U	13.03	0.005
GW30-10-14926	3/31/2010	Borehole	10-2186	1195	0.001	U	0.043	0.000	0.0003	0.0000	0.156	0.001	1.204	0.010	0.001	U	0.02	Not analyzed	8.77	0.05	0.001	U	6.17	0.005
GW30-10-14920	4/12/2010	Development	10-2713	1140.0-1160.9	0.001	U	0.005	0.000	0.0009	0.0000	0.039	0.000	0.375	0.002	0.001	U	0.02	0.23	10.16	0.05	0.001	U	2.52	0.002
GW30-10-14921	4/12/2010	Development	10-2713	1140.0-1160.9	0.001	U	0.003	0.001	0.0010	0.0002	0.036	0.000	0.247	0.001	0.001	U	0.02	0.28	10.18	0.04	0.001	U	2.37	0.002
GW30-10-14929	4/12/2010	Development	10-2712	1140.0-1160.9	0.001	U	0.002	0.000	0.0009	0.0000	0.035	0.000	0.274	0.001	0.001	U	0.02	0.18	10.16	0.06	0.001	U	2.58	0.002

Sample ID	Date Received	Sample Type	ClO4(-) (U)	Co rslt (ppm)	stdev (Co)	Alk-CO3 rslt (ppm)	ALK-CO3 (U)	Cr rslt (ppm)	stdev (Cr)	Cs rslt (ppm)	stdev (Cs)	Cu rslt (ppm)	stdev (Cu)	F(-) ppm	Fe rslt (ppm)	stdev (Fe)	Alk-CO3+HCO3 rslt (ppm)	Hg rslt (ppm)	stdev (Hg)	K rslt (ppm)	stdev (K)	Li rslt (ppm)	stdev (Li)	Mg rslt (ppm)	stdev (Mg)
GW30-10-14925	3/31/2010	Borehole	U	0.001	U	0.8	U	0.003	0.000	0.001	U	0.002	0.000	0.86	0.11	0.00	94.3	0.00009	0.00000	2.18	0.01	0.042	0.003	2.22	0.02
GW30-10-14926	3/31/2010	Borehole	U	0.001	U	0.8	U	0.002	0.000	0.001	U	0.003	0.000	0.48	0.08	0.00	82.5	0.00005	U	1.23	0.01	0.033	0.000	2.80	0.01
GW30-10-14920	4/12/2010	Development	U	0.001	U	0.8	U	0.002	0.000	0.001	U	0.001	U	0.25	0.29	0.00	73.6	0.00005	U	0.78	0.00	0.017	0.000	2.74	0.01
GW30-10-14921	4/12/2010	Development	U	0.001	U	0.8	U	0.003	0.001	0.001	U	0.001	U	0.24	0.33	0.00	71.2	0.00005	U	0.84	0.01	0.022	0.006	2.74	0.01
GW30-10-14929	4/12/2010	Development	U	0.001	U	0.8	U	0.002	0.000	0.001	U	0.001	U	0.23	0.23	0.00	71.3	0.00005	U	0.84	0.00	0.018	0.001	2.73	0.02

Sample ID	Date Received	Sample Type	Mn rslt (ppm)	stdev (Mn)	Mo rslt (ppm)	stdev (Mo)	Na rslt (ppm)	stdev (Na)	Ni rslt (ppm)	stdev (Ni)	NO2 (ppm)	NO2-N rslt	NO3 ppm	NO3-N rslt	C2O4 rslt (ppm)	Pb rslt (ppm)	stdev (Pb)	Lab pH	PO4(-3) rslt (ppm)	Rb rslt (ppm)	stdev (Rb)	Sb rslt (ppm)	stdev (Sb)	Se rslt (ppm)	stdev (Se)	Si rslt (ppm)
GW30-10-14925	3/31/2010	Borehole	0.066	0.004	0.072	0.001	29.49	0.35	0.002	0.000	0.07	0.021	0.84	0.19	0.02	0.0002	U	6.70	0.04	0.001	U	0.001	U	0.001	U	10.4
GW30-10-14926	3/31/2010	Borehole	0.235	0.001	0.008	0.000	15.37	0.05	0.003	0.000	0.1	0.030	1.06	0.24	0.01, U	0.0007	0.0000	6.87	0.01, U	0.001	U	0.001	U	0.001	U	21.6
GW30-10-14920	4/12/2010	Development	0.045	0.002	0.001	0.000	11.72	0.11	0.001	U	0.01	0.003, U	1.54	0.35	0.01, U	0.0002	U	7.53	0.07	0.001	U	0.001	U	0.001	U	32.5
GW30-10-14921	4/12/2010	Development	0.044	0.011	0.001	U	11.11	0.04	0.001	U	0.01	0.003, U	1.52	0.34	0.01, U	0.0002	U	7.19	0.07	0.001	U	0.001	U	0.001	U	32.5
GW30-10-14929	4/12/2010	Development	0.035	0.000	0.001	0.000	11.03	0.08	0.001	U	0.01	0.003, U	1.54	0.35	0.01, U	0.0002	U	7.11	0.07	0.001	U	0.001	U	0.001	U	32.4

Sample ID	Date Received	Sample Type	stdev (Si)	SiO2 rslt (ppm)	stdev (SiO2)	Sn rslt (ppm)	stdev (Sn)	SO4(-2) rslt (ppm)	Sr rslt (ppm)	stdev (Sr)	Th rslt (ppm)	stdev (Th)	Ti rslt (ppm)	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)	U rslt (ppm)	stdev (U)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS (ppm)	Cations	Anions	Balance
GW30-10-14925	3/31/2010	Borehole	0.1	22.2	0.2	0.001	U	3.83	0.038	0.003	0.001	U	0.009	0.000	0.001	U	0.0002	U	0.002	0.000	0.017	0.001	199	1.90	2.30	-0.10
GW30-10-14926	3/31/2010	Borehole	0.1	46.3	0.3	0.001	U	2.85	0.035	0.000	0.001	U	0.003	0.000	0.001	U	0.0002	U	0.001	0.000	0.018	0.000	170	1.40	1.67	-0.09
GW30-10-14920	4/12/2010	Development	0.2	69.5	0.4	0.001	U	2.55	0.045	0.002	0.001	U	0.002	U	0.001	U	0.0004	0.0000	0.007	0.000	0.062	0.002	177	1.28	1.40	-0.05
GW30-10-14921	4/12/2010	Development	0.2	69.6	0.4	0.001	U	2.08	0.052	0.012	0.001	U	0.002	U	0.001	U	0.0005	0.0001	0.009	0.002	0.061	0.011	174	1.25	1.34	-0.04
GW30-10-14929	4/12/2010	Development	0.2	69.4	0.5	0.001	U	2.12	0.043	0.000	0.001	U	0.002	U	0.001	U	0.0004	0.0000	0.007	0.000	0.050	0.000	173	1.24	1.35	-0.04

* U = Not detected.

Appendix C

Borehole Video Logging
(on DVD included with this document)

Appendix D

Geophysical Logs
(on CD included with this document)

Appendix E

Aquifer Testing Report

E-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests conducted in April 2010 at well R-30 located at Technical Area 49 (TA-49) at Los Alamos National Laboratory (the Laboratory). The tests on R-30 were conducted to evaluate the hydraulic properties of the sediments in which the well was completed.

Testing consisted of brief trial pumping of R-30, background water level data collection, and a 24-h constant-rate pumping test. As with most of the R-well pumping tests conducted on the Pajarito Plateau (the Plateau), an inflatable packer system was used in R-30 to minimize the effects of casing storage on the test data.

Conceptual Hydrogeology

Well R-30 is drilled into sediments of the Puye Formation. The well was completed with 20.9 ft of 5-in. stainless-steel well screen from 1140.0 to 1160.9 ft below ground surface (bgs). The static water level measured on April 11 was 1124.1 ft bgs, 15.9 ft above the top of the well screen. The estimated ground surface elevation at R-30 was 7075 ft above mean sea level (amsl), making the water level approximately 5950.9 ft amsl.

There were no distinctive aquitards or other tight zones identified for R-30, so the permeability distribution of the saturated zone and the effective aquifer thickness in the vicinity of the well were not well defined. Temporary advancement of the drill casing to 1196 ft showed the borehole was still in Puye Formation sediments at that depth.

R-30 Testing

Well R-30 was tested from April 12 to 16, 2010. Testing consisted of brief trial pumping on April 12, background data collection, and a 24-h constant-rate pumping test that began on April 14.

Two trial tests were conducted on April 12. Trial 1 was conducted at a discharge rate of 7.1 gallons per minute (gpm) for 40 min from 9:00 to 9:40 a.m., followed by 80 min of recovery until 11:00 a.m.

Trial 2 was conducted for 60 min, from 11:00 a.m. to 12:00 p.m., at a discharge rate of 7.1 gpm. Following shutdown, recovery/background data were recorded for 2760 min, until 10:00 a.m. on April 14.

At 10:00 a.m. on April 14, the 24-h pumping test began at a rate of 6.6 gpm. Pumping continued for 1440 min until 10:00 a.m. on April 15 when the pump was shut off. Following shutdown, recovery measurements were recorded for 1440 min until 10:00 a.m. on April 16 when the pump was pulled from the well.

E-2.0 BACKGROUND DATA

The background water-level data collected in conjunction with running the pumping tests allow the analyst to see what water-level fluctuations occur naturally in the aquifer and help distinguish between water-level changes caused by conducting the pumping test and changes associated with other causes.

Background water-level fluctuations have several causes, among them barometric pressure changes, operation of other wells in the aquifer, Earth tides, and long-term trends related to weather patterns. The background data hydrographs from the monitored wells were compared to barometric pressure data from the area to determine if a correlation existed.

Previous pumping tests on the plateau have demonstrated a barometric efficiency for most wells of between 90% and 100%. Barometric efficiency is defined as the ratio of water-level change divided by barometric pressure change, expressed as a percentage. In the initial pumping tests conducted on the early R-wells, downhole pressure was monitored using a vented pressure transducer. This equipment measures the difference between the total pressure applied to the transducer and the barometric pressure, this difference being the true height of water above the transducer.

Subsequent pumping tests, including at R-30, have utilized nonvented transducers. These devices record the total pressure on the transducer, that is, the sum of the water height plus the barometric pressure. This results in an attenuated “apparent” hydrograph in a barometrically efficient well. Take as an example a 90% barometrically efficient well. When monitored using a vented transducer, an increase in barometric pressure of 1 unit causes a decrease in recorded downhole pressure of 0.9 unit because the water level is forced downward 0.9 unit by the barometric pressure change. However, using a nonvented transducer, the total measured pressure increases by 0.1 unit (the combination of the barometric pressure increase and the water-level decrease). Thus, the resulting apparent hydrograph changes by a factor of 100 minus the barometric efficiency, and in the same direction as the barometric pressure change, rather than in the opposite direction.

Barometric pressure data were obtained from TA-54 tower site from the Waste and Environmental Services Division-Environmental Data and Analysis (WES-EDA). The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is approximately 7075 ft amsl. The static water level in R-30 was 1124.1 ft below land surface, making the calculated water-table elevation 5950.9 ft amsl. Therefore, the measured barometric pressure data from TA-54 had to be adjusted to reflect the pressure at the elevation of the water table within R-30.

The following formula was used to adjust the measured barometric pressure data:

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R}\left(\frac{E_{R-30}-E_{TA54}}{T_{TA54}}+\frac{E_{WT}-E_{R-30}}{T_{WELL}}\right)\right] \qquad \textbf{Equation E-1}$$

where, P_{WT} = barometric pressure at the water table inside R-30

P_{TA54} = barometric pressure measured at TA-54

g = acceleration of gravity, in m/sec^2 (9.80665 m/s^2)

R = gas constant, in J/kg/degree kelvin (287.04 J/kg/degree kelvin)

E_{R-30} = land surface elevation at R-30 site, in feet (approximately 7075 ft)

E_{TA54} = elevation of barometric pressure measuring point at TA-54, in feet (6548 ft)

E_{WT} = elevation of the water level in R-30, in feet (approximately 5950.9 ft)

T_{TA54} = air temperature near TA-54, in degrees kelvin (assigned a value of 54.6 degrees Fahrenheit, or 285.7 degrees kelvin)

T_{WELL} = air temperature inside R-30, in degrees kelvin (assigned a value of 60.8 degrees Fahrenheit, or 289.2 degrees kelvin)

This formula is an adaptation of an equation WES-EDA provided. It can be derived from the ideal gas law and standard physics principles. An inherent assumption in the derivation of the equation is that the air temperature between TA-54 and the well is temporally and spatially constant and that the temperature of the air column in the well is similarly constant.

The corrected barometric pressure data reflecting pressure conditions at the water table were compared with the water-level hydrograph to discern the correlation between the two and determine whether water level corrections would be needed before data analysis.

E-3.0 IMPORTANCE OF EARLY DATA

When pumping or recovery first begins, the vertical extent of the cone of depression is limited to approximately the well screen length, the filter pack length, or the aquifer thickness in relatively thin permeable strata. For many pumping tests on the Plateau, the early pumping period is the only time the effective height of the cone of depression is known with certainty because, soon after startup, the cone of depression expands vertically through permeable materials above and/or below the screened interval. Thus, the early data often offer the best opportunity to obtain hydraulic conductivity information because conductivity would equal the earliest-time transmissivity divided by the well screen length.

Unfortunately, in many pumping tests, casing-storage effects dominate the early-time data, potentially hindering the effort to determine the transmissivity of the screened interval. The duration of casing-storage effects can be estimated using the following equation (Schafer 1978, 098240).

$$t_c = \frac{0.6\left(D^2 - d^2\right)}{\frac{Q}{s}}$$

Equation E-2

where, t_c = duration of casing storage effect, in minutes

D = inside diameter of well casing, in inches

d = outside diameter of column pipe, in inches

Q = discharge rate, in gallons per minute

s = drawdown observed in pumped well at time t_c, in feet

The calculated casing storage time is quite conservative. Often, the data show that significant effects of casing storage have dissipated after about half the computed time.

For wells screened across the water table (not applicable here), there can be an additional storage contribution from the filter pack around the screen. The following equation provides an estimate of the storage duration accounting for both casing and filter pack storage.

$$t_c = \frac{0.6\left[\left(D^2 - d^2\right) + S_y\left(D_B^2 - D_C^2\right)\right]}{\frac{Q}{s}}$$

Equation E-3

where, S_y = short term specific yield of filter media (typically 0.2)

D_B = diameter of borehole, in inches

D_C = outside diameter of well casing, in inches

This equation was derived from Equation E-2 on a proportional basis by increasing the computed time in direct proportion to the additional volume of water expected to drain from the filter pack. (To prove this, note that the left hand term within the brackets is directly proportional to the annular area [and volume] between the casing and drop pipe while the right hand term is proportional to the area [and volume] between the borehole and the casing, corrected for the drainable porosity of the filter pack. Thus, the summed term within the brackets accounts for all of the volume [casing water and drained filter pack water] appropriately.)

In some instances, it is possible to eliminate casing storage effects by setting an inflatable packer above the tested screen interval before conducting the test. Therefore, this option has been implemented for the R-well testing program, including R-30.

E-4.0 TIME-DRAWDOWN METHODS

Time-drawdown data can be analyzed using a variety of methods. Among them is the Theis method (1934-1935, 098241). The Theis equation describes drawdown around a well as follows:

$$s = \frac{114.6Q}{T} W(u)$$ **Equation E-4**

where,

$$W(u) = \int_u^\infty \frac{e^{-x}}{x} dx$$ **Equation E-5**

and

$$u = \frac{1.87 r^2 S}{Tt}$$ **Equation E-6**

and where, s = drawdown, in feet

Q = discharge rate, in gallons per minute

T = transmissivity, in gallons per day per foot

S = storage coefficient (dimensionless)

t = pumping time, in days

r = distance from center of pumpage, in feet

To use the Theis method of analysis, the time-drawdown data are plotted on log-log graph paper. Then, Theis curve matching is performed using the Theis type curve—a plot of the Theis well function $W(u)$ versus $1/u$. Curve matching is accomplished by overlaying the type curve on the data plot and, while keeping the coordinate axes of the two plots parallel, shifting the data plot to align with the type curve, effecting a match position. An arbitrary point, referred to as the match point, is selected from the overlapping parts of the plots. Match-point coordinates are recorded from the two graphs, yielding four values: $W(u)$: $1/u$, s, and t. Using these match-point values, transmissivity and storage coefficient are computed as follows:

$$T = \frac{114.6Q}{s} W(u)$$

Equation E-7

$$S = \frac{Tut}{2693r^2}$$

Equation E-8

where, T = transmissivity, in gallons per day per foot

S = storage coefficient

Q = discharge rate, in gallons per minute

$W(u)$ = match-point value

s = match-point value, in feet

u = match-point value

t = match-point value, in minutes

An alternative solution method applicable to time-drawdown data is the Cooper-Jacob method (1946, 098236), a simplification of the Theis equation that is mathematically equivalent to the Theis equation for most pumped well data. The Cooper-Jacob equation describes drawdown around a pumping well as follows:

$$s = \frac{264Q}{T} \log \frac{0.3Tt}{r^2 S}$$

Equation E-9

The Cooper-Jacob equation is a simplified approximation of the Theis equation and is valid whenever the *u* value is less than about 0.05. For small radius values (e.g., corresponding to borehole radii), u is less than 0.05 at very early pumping times and therefore is less than 0.05 for most or all measured drawdown values. Thus, for the pumped well, the Cooper-Jacob equation usually can be considered a valid approximation of the Theis equation.

According to the Cooper-Jacob method, the time-drawdown data are plotted on a semilog graph, with time plotted on the logarithmic scale. Then a straight line of best fit is constructed through the data points, and transmissivity is calculated using the following:

$$T = \frac{264Q}{\Delta s}$$

Equation E-10

where, T = transmissivity, in gallons per day per foot

Q = discharge rate, in gallons per minute

Δs = change in head over one log cycle of the graph, in feet

Because many of the test wells completed on the Plateau are severely partially penetrating, an alternate solution considered for assessing aquifer conditions is the Hantush equation for partially penetrating wells (Hantush 1961, 098237; Hantush 1961, 106003). The Hantush equation is as follows:

Equation E-11

$$s = \frac{Q}{4\pi T}\left[W(u) + \frac{2b^2}{\pi^2(l-d)(l'-d')}\sum_{n=1}^{\infty}\frac{1}{n^2}\left(\sin\frac{n\pi l}{b} - \sin\frac{n\pi d}{b}\right)\left(\sin\frac{n\pi l'}{b} - \sin\frac{n\pi d'}{b}\right)W\left(u, \sqrt{\frac{K_z}{K_r}}\frac{n\pi r}{b}\right)\right]$$

where, in consistent units, s, Q, T, t, r, S, and u are as previously defined and

b = aquifer thickness

d = distance from top of aquifer to top of well screen in pumped well

l = distance from top of aquifer to bottom of well screen in pumped well

d' = distance from top of aquifer to top of well screen in observation well

l' = distance from top of aquifer to bottom of well screen in observation well

K_z = vertical hydraulic conductivity

K_r = horizontal hydraulic conductivity

In this equation, $W(u)$ is the Theis well function and $W(u,\beta)$ is the Hantush well function for leaky aquifers where:

$$\beta = \sqrt{\frac{K_z}{K_r}}\frac{n\pi r}{b}$$ **Equation E-12**

Note that for single-well tests, $d = d'$ and $l = l'$.

E-5.0 RECOVERY METHODS

Recovery data were analyzed using the Theis recovery method. This is a semilog analysis method similar to the Cooper-Jacob procedure.

In this method, residual drawdown is plotted on a semilog graph versus the ratio t/t', where t is the time since pumping began and t' is the time since pumping stopped. A straight line of best fit is constructed through the data points, and T is calculated from the slope of the line as follows:

$$T = \frac{264Q}{\Delta s}$$ **Equation E-13**

The recovery data are particularly useful compared with time-drawdown data. Because the pump is not running, spurious data responses associated with dynamic discharge rate fluctuations are eliminated. The result is that the data set is generally “smoother” and easier to analyze.

E-6.0 SPECIFIC CAPACITY METHOD

The specific capacity of the pumped well can be used to obtain a lower-bound value of hydraulic conductivity. The hydraulic conductivity is computed using formulas that are based on the assumption that the pumped well is 100% efficient. The resulting hydraulic conductivity is the value required to sustain the observed specific capacity. If the actual well is less than 100% efficient, it follows that the actual hydraulic conductivity would have to be greater than calculated to compensate for well inefficiency. Thus, because the efficiency is not known, the computed hydraulic conductivity value represents a lower bound. The actual conductivity is known to be greater than or equal to the computed value.

For fully penetrating wells, the Cooper-Jacob equation can be iterated to solve for the lower-bound hydraulic conductivity. However, the Cooper-Jacob equation (assuming full penetration) ignores the contribution to well yield from permeable sediments above and below the screened interval. To account for this contribution, it is necessary to use a computation algorithm that includes the effects of partial penetration. One such approach was introduced by Brons and Marting (1961, 098235) and augmented by Bradbury and Rothchild (1985, 098234).

Brons and Marting introduced a dimensionless drawdown correction factor, s_P, approximated by Bradbury and Rothschild as follows:

$$s_P = \frac{1-\frac{L}{b}}{\frac{L}{b}}\left[\ln\frac{b}{r_w} - 2.948 + 7.363\frac{L}{b} - 11.447\left(\frac{L}{b}\right)^2 + 4.675\left(\frac{L}{b}\right)^3\right] \qquad \textbf{Equation E-14}$$

In this equation, L is the well screen length, in ft. Incorporating the dimensionless drawdown parameter, the conductivity is obtained by iterating the following formula:

$$K = \frac{264Q}{sb}\left(\log\frac{0.3Tt}{r_w^2 S} + \frac{2s_P}{\ln 10}\right) \qquad \textbf{Equation E-15}$$

The Brons and Marting procedure can be applied to both partially penetrating and fully penetrating wells.

To apply this procedure, a storage coefficient value must be assigned. Unconfined conditions were assumed for R-30 because of the modest water level rise above the well screen and the water table falling within the Puye Formation. Storage coefficient values for unconfined conditions can be expected to range from about 0.01 to 0.25 (Driscoll 1986, 104226). A value of 0.1 was used for the R-30 calculations. The calculation result is not particularly sensitive to the choice of storage coefficient value, so a rough estimate of the storage coefficient is generally adequate to support the calculations.

The analysis also requires assigning a value for the saturated aquifer thickness, b. For the purposes of this exercise, an arbitrary saturated thickness of 100 ft was assigned. As long as the aquifer thickness is greater than the well screen length, the calculation result is not especially sensitive to the selected value because sediments far above and/or below the screen do not contribute significantly to the specific capacity.

E-7.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-30 tests were plotted along with barometric pressure to determine the barometric effect on water levels.

Figure E-7.0-1 shows aquifer pressure data from R-30 along with barometric pressure data from TA-54 that have been corrected to equivalent barometric pressure in feet of water at the water table. The R-30 data are referred to in the figure as the "apparent hydrograph" because the measurements reflect the sum of water pressure and barometric pressure recorded using a nonvented pressure transducer. The times of the pumping periods for the R-30 pumping tests are included on the figure for reference.

The data in Figure E-7.0-1 showed virtually no change in aquifer pressure during periods of large barometric pressure change. This finding suggested a barometric efficiency of close to 100% and implied that water-level measurements did not have to be adjusted for changes in barometric pressure.

Despite the noise in the data signal, there appeared to be a subtle fluctuation in aquifer pressure as evidenced by a tiny "ripple" in the data trace. This was investigated by plotting the hydrograph on an expanded scale, as shown in Figure E-7.0-2. A rolling average plot was used to try to reduce the noise in the signal. The resulting plot showed a regular oscillation in the aquifer pressure of just under a hundredth of a foot, with a diurnal frequency. This pattern appeared to be unrelated to barometric pressure changes. It was believed that the tiny oscillations were Earth tide effects.

E-8.0 WELL R-30 DATA ANALYSIS

This section presents the data obtained from the R-30 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery for trials 1 and 2 as well as the 24-h constant-rate pumping test.

E-8.1 Well R-30 Trial 1

Figure E-8.1-1 shows a semilog plot of the drawdown data collected from trial 1. Pumping began with an empty drop pipe so that the pump operated initially against low head pressure. Therefore, to avoid over pumping the well and pulling the water level into the well screen during startup (causing dewatering of the filter pack and subsequent storage effects), the pump was started at a low speed which then was increased gradually for the first 11 min of operation. While the pump speed was increased slowly, the drop pipe filled gradually, increasing the backpressure on the pump. The combination of these two simultaneous dynamic effects (changing pump speed and backpressure) gave rise to the unusual drawdown curve shown for the first 11 min of the pumping test. Once water reached the surface, a final valve adjustment was made, reducing the discharge rate to 7.1 gpm.

The data collected after the discharge rate had stabilized were plotted on the expanded-scale graph shown in Figure E-8.1-2. The transmissivity computed from this portion of the drawdown curve was 5610 gallons per day (gpd) per foot. Because this value was based on data recorded after more than 20 min of pumping, it was likely that the cone of depression had expanded vertically a significant distance. Therefore, there was no way to know what the effective thickness was corresponding to this transmissivity value.

Figure E-8.1-3 shows the recovery data collected following shutdown of the trial 1 pumping test. The early slope supported a transmissivity calculation of 1430 gpd/ft. It was assumed that this value represented the transmissivity of just the 20.9-ft-thick screened interval, making the hydraulic conductivity 68 gpd/ft^2, or 9.1 ft/d.

The subsequent data showed a steadily decreasing slope with time, likely associated with ongoing vertical growth of the cone of depression through a progressively thicker sequence of Puye Formation sediments. Figure E-8.1-4 shows an expanded-scale plot of the late recovery data. Most of the data showed an average transmissivity of about 5490 gpd/ft. There was no way to know what effective sediment thickness corresponded to this transmissivity value. Furthermore, the data would have supported computation of almost any transmissivity value, depending on which segment of data was used for the calculation.

The data spikes shown at the end of the recovery period corresponded to deflating and reinflating the packer before trial 2 began as a precaution to expel any air that may have come out of solution and collected beneath the inflatable packer during trial 1.

E-8.2 Well R-30 Trial 2

Figure E-8.2-1 shows a semilog plot of the drawdown data collected from trial 2. The early data supported a transmissivity calculation of 1500 gpd/ft. Based on the well screen length of 20.9 ft, this value suggested an average hydraulic conductivity for the screened interval of 72 gpd/ft^2, or 9.6 ft/d.

The late data produced a transmissivity value of 4790 gpd/ft for a greater, but unknown, thickness of sediments.

The first few data points in Figure E-8.2-1 fell off the line of fit shown in the graph. This was likely because the u value corresponding to these data was greater than 0.05. Therefore, a log-log plot of the data was prepared and analyzed by Theis curve matching, as shown in Figure E-8.2-2. This analysis produced an estimated transmissivity for the screened interval of 1400 gpd/ft, making the hydraulic conductivity 67 gpd/ft^2, or 9.0 ft/d.

Figure E-8.2-3 shows the recovery data collected following shutdown of the trial 2 pumping test. The early data yielded a transmissivity of 1480 gpd/ft, with a corresponding average hydraulic conductivity for the screened interval of 71 gpd/ft^2, or 9.5 ft/d.

The very early data points fell off the line of fit shown in Figure E-8.2-3, likely because the u value was greater than 0.05. The data were plotted on the log-log graph shown in Figure E-8.2-4 and analyzed by Theis curve matching. This analysis revealed a screen interval transmissivity of 1500 gpd/ft, with a corresponding hydraulic conductivity of 72 gpd/ft^2, or 9.6 ft/d.

The late recovery data showed a continuous flattening of the data trace, again largely a result of vertical growth of the cone of depression above and below the well screen. The expanded-scale plot shown in Figure E-8.2-5 supported a transmissivity calculation of 5960 gpd/ft for a particular segment of data. There was no way to know what the corresponding effective aquifer thickness was. Furthermore, a variety of other transmissivity values could have been computed, depending on which data segment would have been used to establish the line of fit.

The very late data in Figure E-8.2-5 showed essentially no change in water level over time, suggesting complete (and premature) recovery. This may have been attributable to hysteretic effects associated with changing storage coefficient. In unconfined aquifers, rate of recovery can be more rapid than that of drawdown because of a smaller effective storage coefficient during recovery. During pumping the capillary fringe above the water table increases in thickness, while during recovery it gets thinner (Bevan et al. 2005, 105186). If the rate of thinning during recovery exceeds the rate of growth during pumping, the effective storage coefficient during recovery will be less than that during pumping, resulting in a more rapid recovery rate than drawdown rate. Additionally, as the water table rebounds during recovery, it can trap air in the previously dewatered pore spaces, further decreasing the effective recovery storage coefficient. These effects tend to result in premature water-level recovery and contribute to exaggerated flattening of the late part of the recovery curve.

E-8.3 Well R-30 24-H Constant-Rate Pumping Test

Figure E-8.3-1 shows a semilog plot of the drawdown data collected during the 24-h pumping test. Data recorded during the first minute of pumping showed exaggerated drawdown followed by a rebound in level. This effect occurred because the upper portion of the drop pipe had been drained at the conclusion of the trial 2 pumping test to prevent freezing overnight. When pumping began, the initial discharge rate was elevated somewhat as the drop pipe refilled. Once the pipe was full, the partially closed valve in the discharge line caused backpressure which decreased the pumping rate and allowed rebound of the pumping water level. The dynamic response of water refilling the drop pipe and then encountering the backpressure valve prevented calculating the screen interval transmissivity.

Data recorded after the pumping rate stabilized yielded a transmissivity of 5040 gpd/ft, corresponding to some unknown sediment thickness greater than the well screen length.

Data obtained over the last several hours of pumping showed a substantially flatter slope, as indicated on the expanded-scale plot shown in Figure E-8.3-2. This severe flattening could have had several causes, including continued vertical growth of the cone of depression (partial penetration effects), delayed yield of the unconfined aquifer, a lateral increase in hydraulic conductivity and transmissivity away from the well, and/or leakage effects.

Figure E-8.3-3 shows the recovery data recorded following the 24-h pumping test. Analysis of the early data yielded a transmissivity of 1470 gpd/ft, making the hydraulic conductivity of the screened interval 70 gpd/ft^2, or 9.4 ft/d.

The data were plotted on the log-log graph shown in Figure E-8.3-4 so that Theis curve matching could be performed. This analysis produced a transmissivity of 1550 gpd/ft and a hydraulic conductivity of 74 gpd/ft^2, or 9.9 ft/d.

The late recovery data showed nearly complete recovery in a short time, likely from hysteretic effects.

E-8.4 Well R-30 Recovery Data Comparison

The recovery data from the trial tests and the 24-h test were plotted in Figure E-8.4-1 so they could be compared. Theoretically, with the exception of just the first few data points, the curves should be identical for identical discharge rates (trials 1 and 2, for example). The data for a different pumping rate should be scaled back slightly according to the change in rate.

As Figure E-8.4-1 shows, however, the recovery data from trials 1 and 2 were not identical, as would be expected, but differed slightly. Furthermore, the recovery data from the 24-h test deviated radically from the trial test data, even though only a slight difference would be expected theoretically, based on the 6.6-gpm pumping rate during the 24-h test versus 7.1 gpm for the trial tests.

The discrepancy in the recovery plots provided additional evidence that hysteretic effects contributed to the observed recovery data response from the pumping tests.

E-8.5 Well R-30 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound hydraulic conductivity value for the portion of the aquifer penetrated by the R-30 well screen to provide a frame of reference for evaluating the foregoing analyses.

During the 24-h pumping test, the discharge rate was 6.6 gpm for 1440 min, with a drawdown of 3.24 ft, making the specific capacity 2.04 gpm/ft at that time. In addition to specific capacity and pumping time, other input values used in the calculations included a storage coefficient value of 0.1, an arbitrary aquifer thickness of 100 ft, and a borehole radius of 0.60 ft (inferred from the volume of filter pack required to backfill the screen zone).

Applying the Brons and Marting method to these inputs yielded a lower-bound hydraulic conductivity of 84 gpd/ft^2, or 11.3 ft/d. The pumping test analyses, on the other hand, suggested an average screen interval transmissivity of about 1480 gpd/ft and hydraulic conductivity of around 71 gpd/ft^2, or 9.5 ft/d. Thus, the lower-bound estimate was greater than the pumping test value. The values were fairly close, however, with a difference of just 15%. Thus, the specific capacity data were considered consistent with the pumping test results. Heterogeneous effects could have contributed to the greater lower-bound hydraulic conductivity estimate. For example, the sediments above and/or below the screen may have a greater hydraulic conductivity than the screen zone, resulting in the lower-bound hydraulic conductivity value exceeding the screen zone value.

E-9.0 SUMMARY

Constant-rate pumping tests were conducted on R-30. The tests were performed to gain an understanding of the hydraulic characteristics of the Puye Formation sediments in which R-30 is screened. Several observations and conclusions were drawn for the tests as summarized below.

A comparison of barometric pressure and R-30 water-level data suggested a barometric efficiency near 100%. Tiny, regular fluctuations in the hydrograph showed diurnal Earth tide effects having a magnitude of slightly less than 0.01 ft.

Transmissivity values computed from early data averaged 1480 gpd/ft, making the average hydraulic conductivity of the screened interval 71 gpd/ft^2, or 9.5 ft/d. Later data produced an average transmissivity of about 5400 gpd/ft although it was not possible to know the effective aquifer thickness corresponding to this transmissivity.

R-30 produced 6.6 gpm with 3.24 ft of drawdown after 1440 min of pumping, resulting in a specific capacity of 2.04 gpm/ft at that particular pumping time. The corresponding computed lower-bound hydraulic conductivity value was 84 gpd/ft^2, similar in order of magnitude to the pumping test values.

The very late pumping data from the 24-h pumping test showed near stabilization. This effect could have been caused by one or more of the following: vertical growth of the cone of depression (partial penetration effects), delayed yield, lateral increase in hydraulic conductivity at a distance from the well, or leakage.

E-10.0 REFERENCES

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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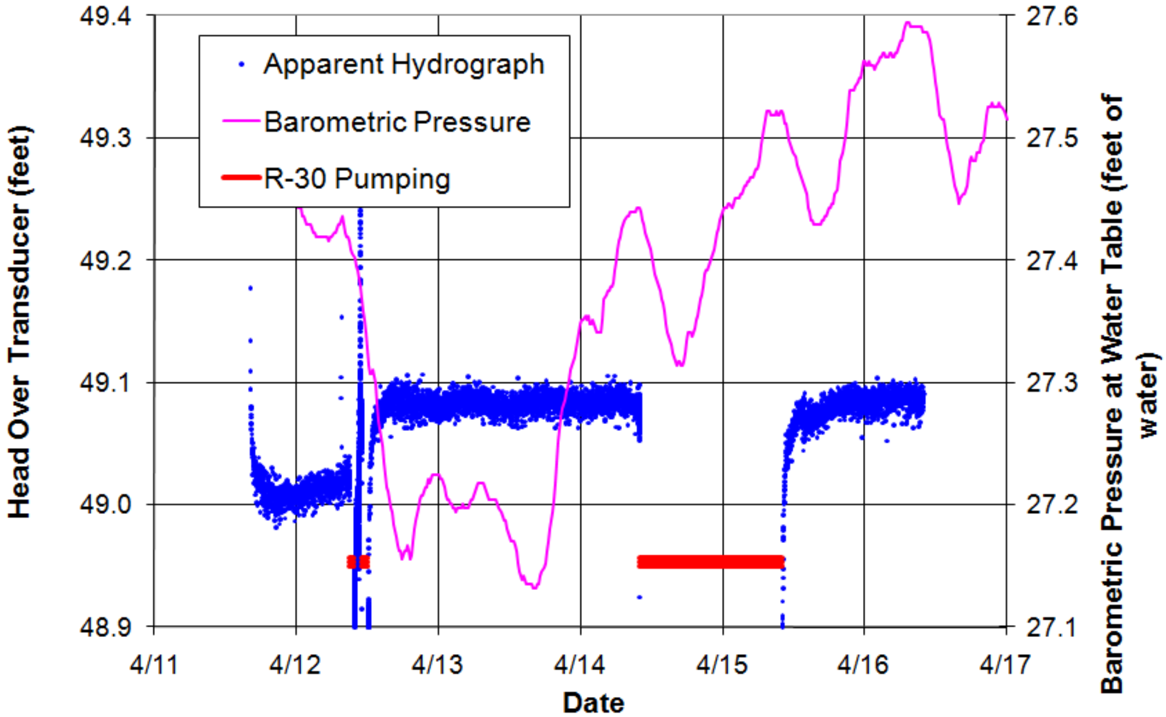


Figure E-7.0-1 Well R-30 apparent hydrograph

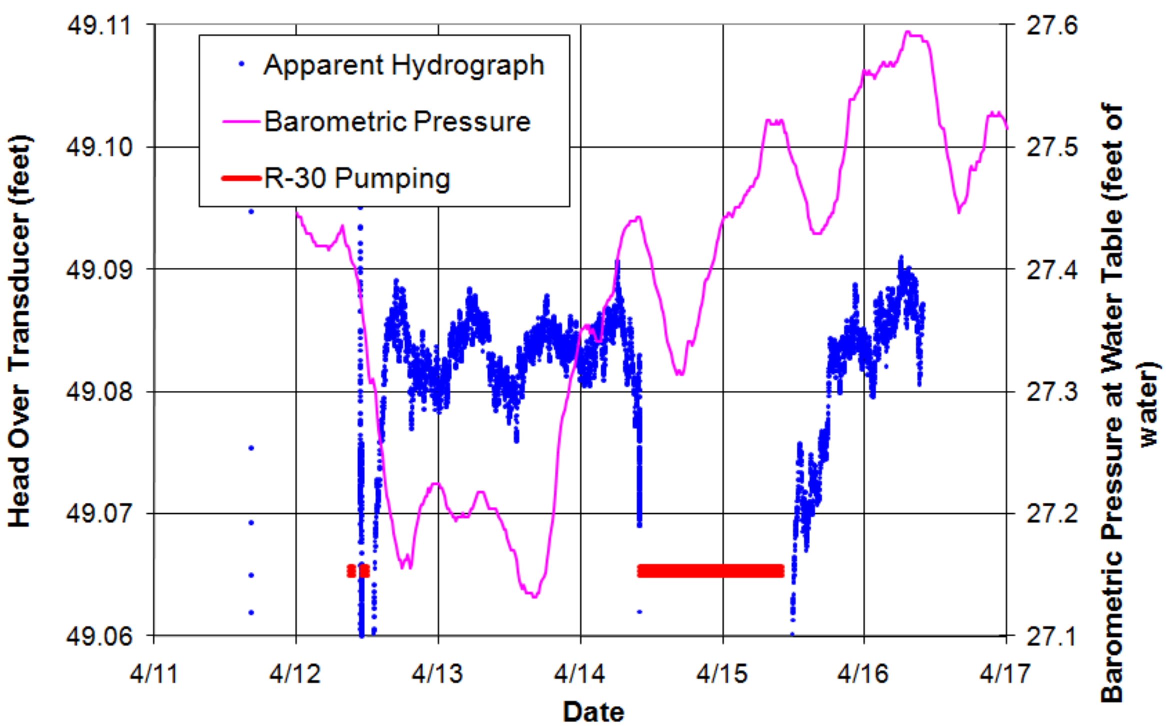


Figure E-7.0-2 Well R-30 rolling average apparent hydrograph

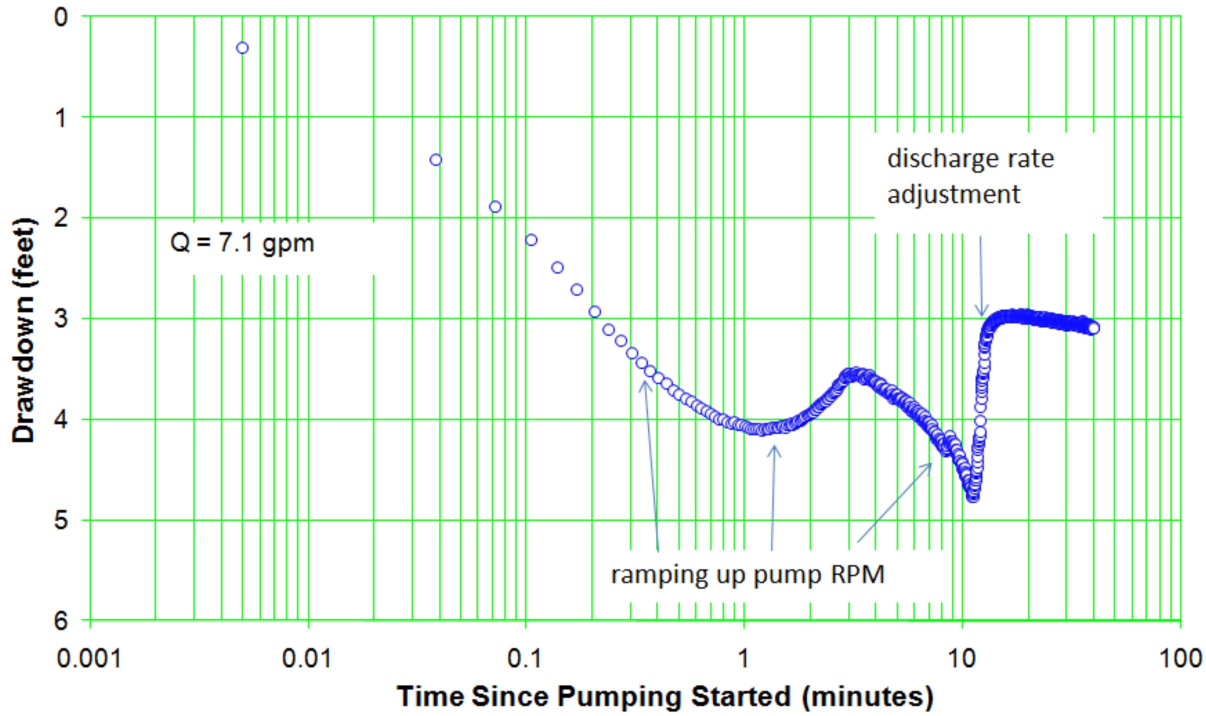


Figure E-8.1-1 Well R-30 trial 1 drawdown

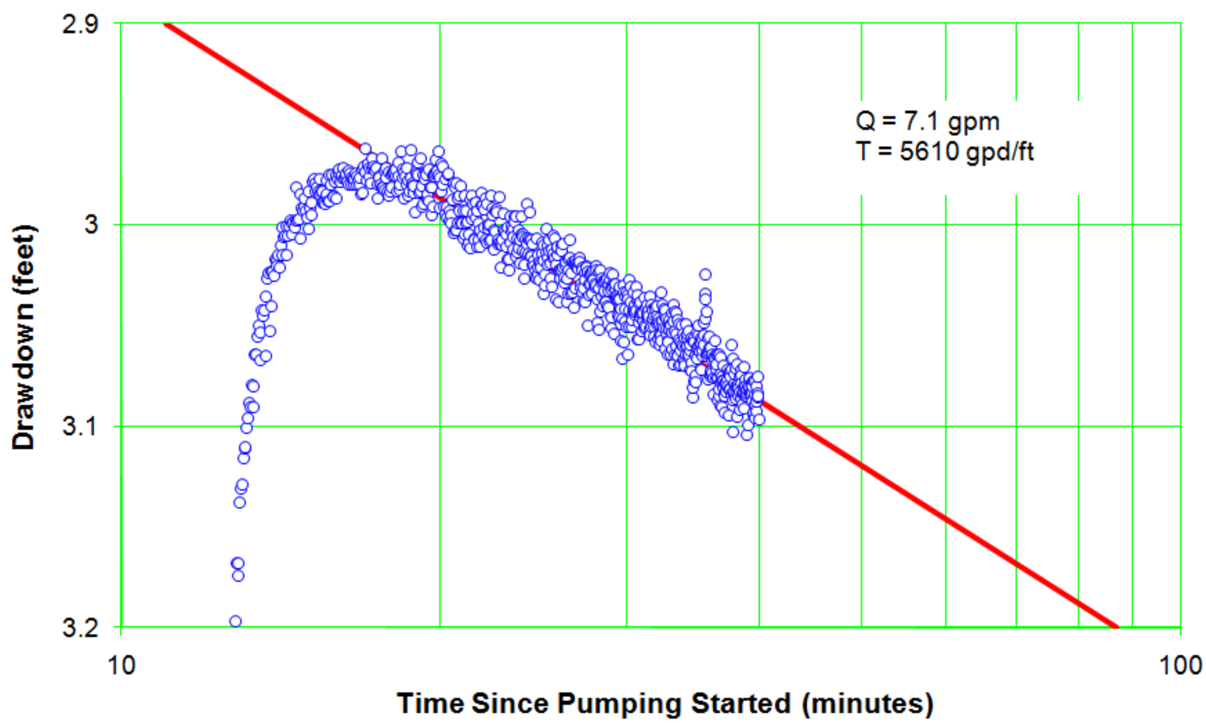


Figure E-8.1-2 Well R-30 trial 1 drawdown—expanded scale

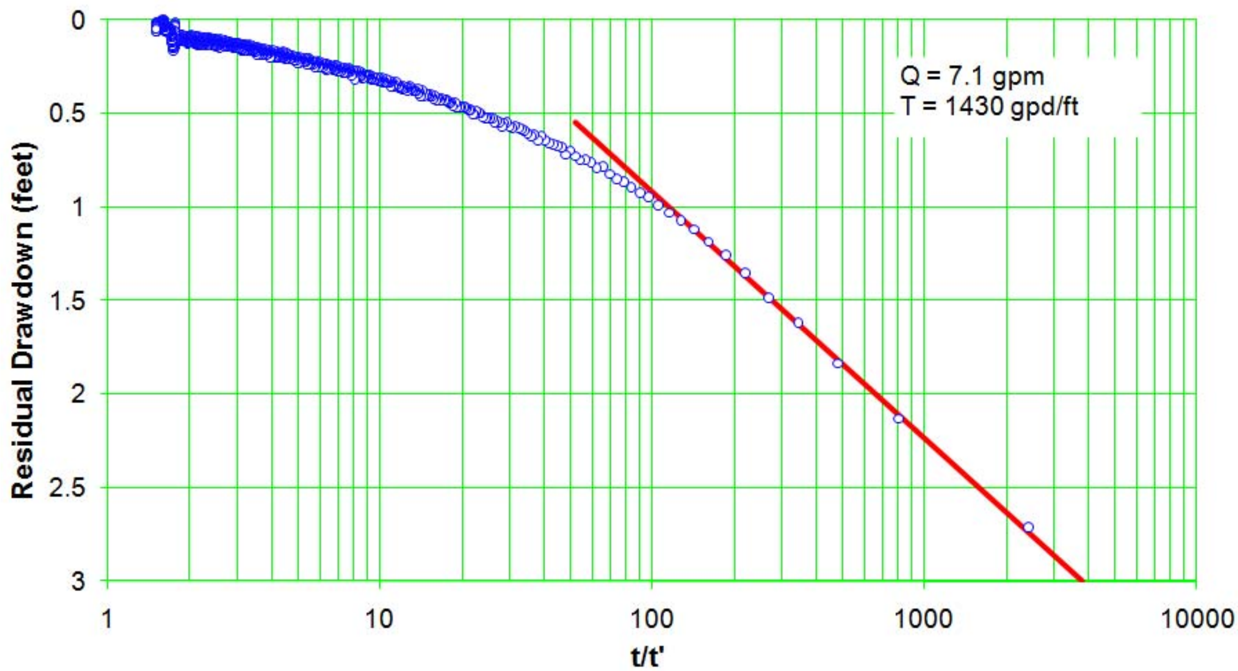


Figure E-8.1-3 Well R-30 trial 1 recovery

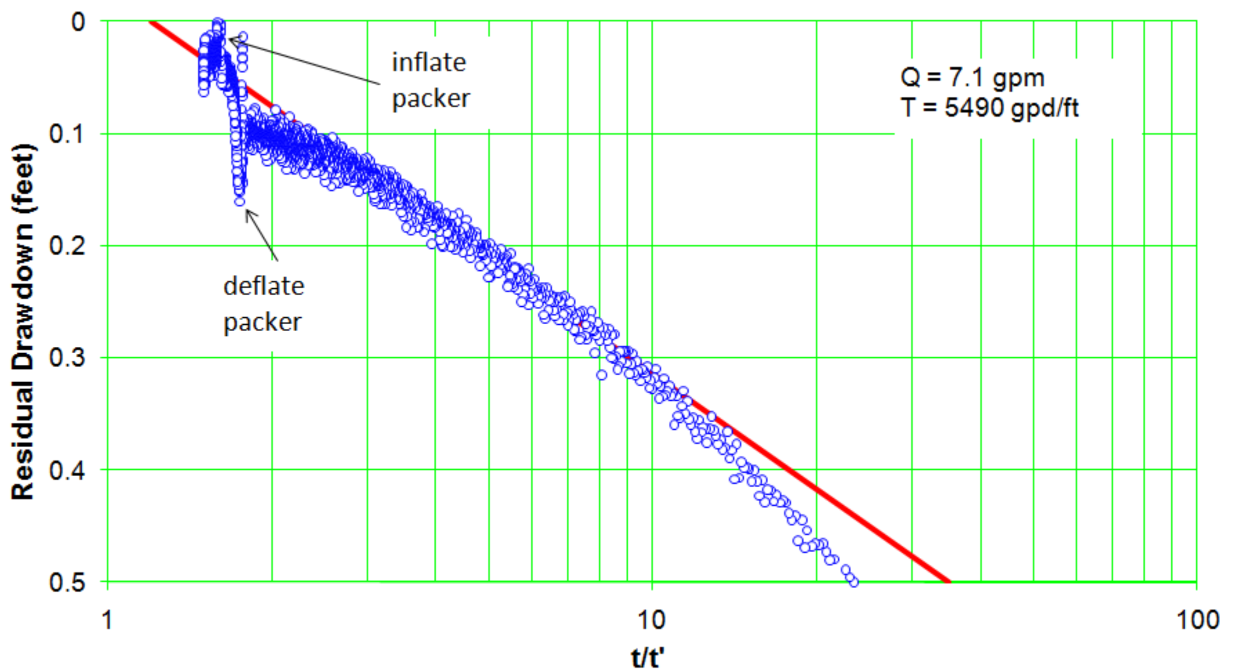


Figure E-8.1-4 Well R-30 trial 1 recovery—expanded scale

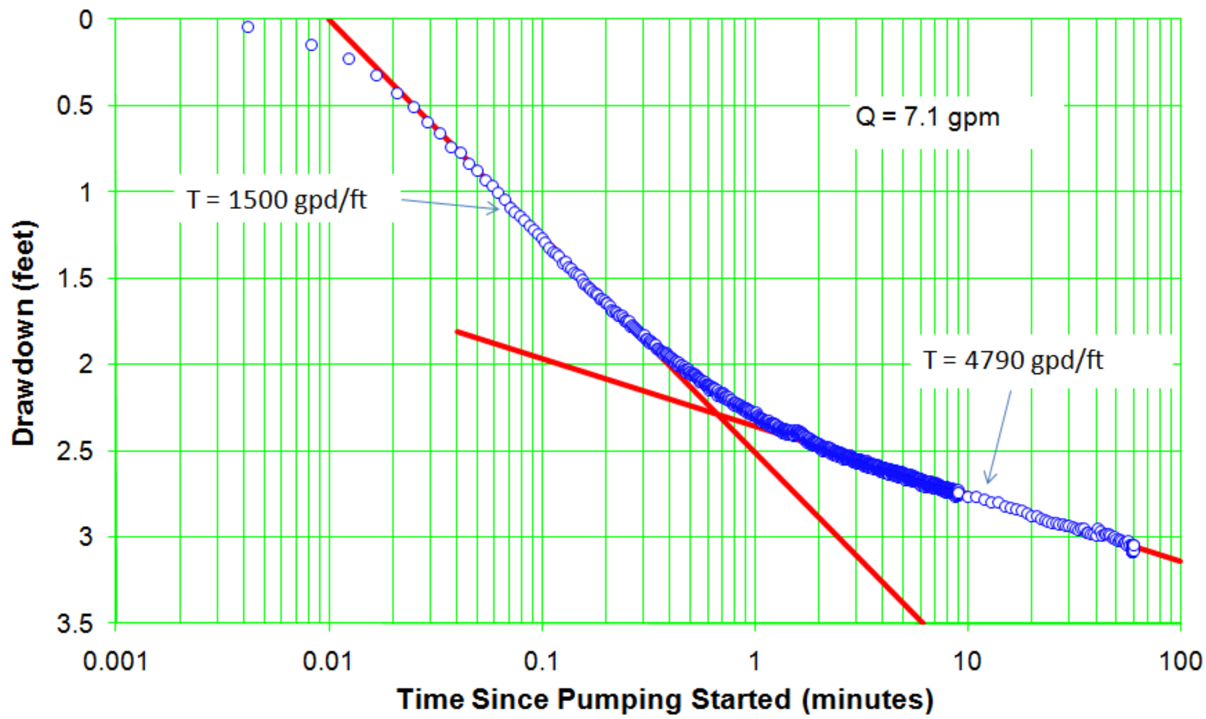


Figure E-8.2-1 Well R-30 trial 2 drawdown

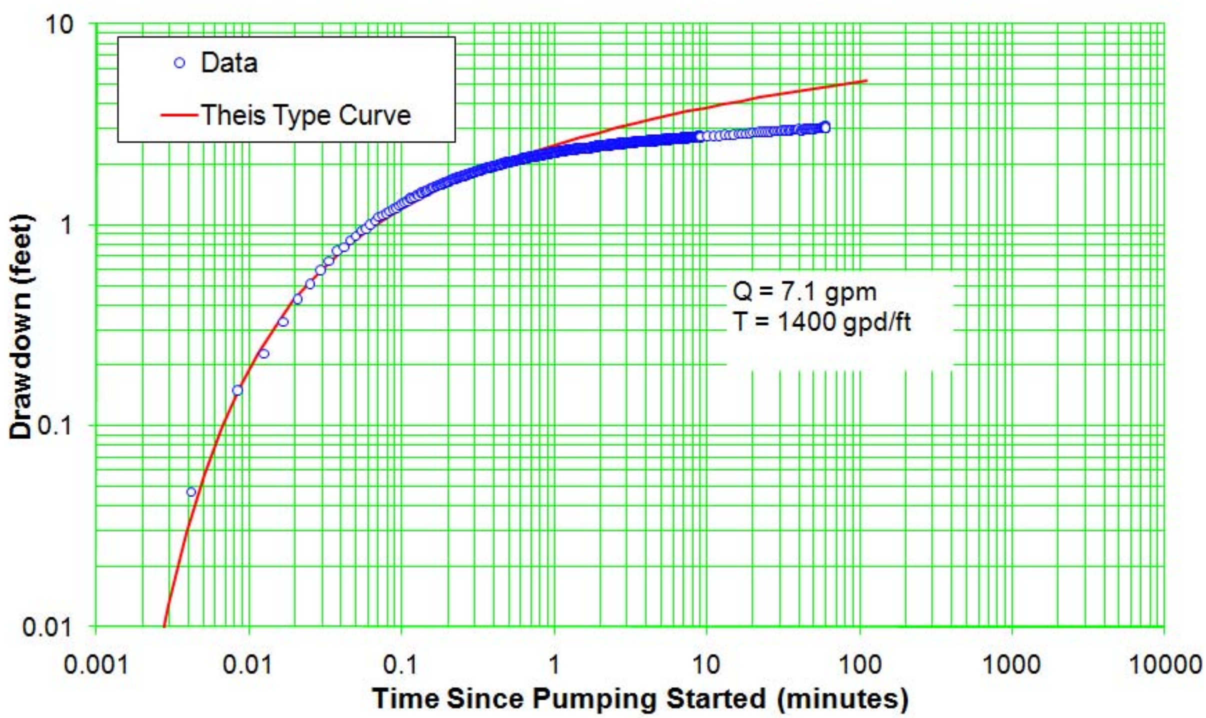


Figure E-8.2-2 Theis analysis of well R-30 trial 2 drawdown

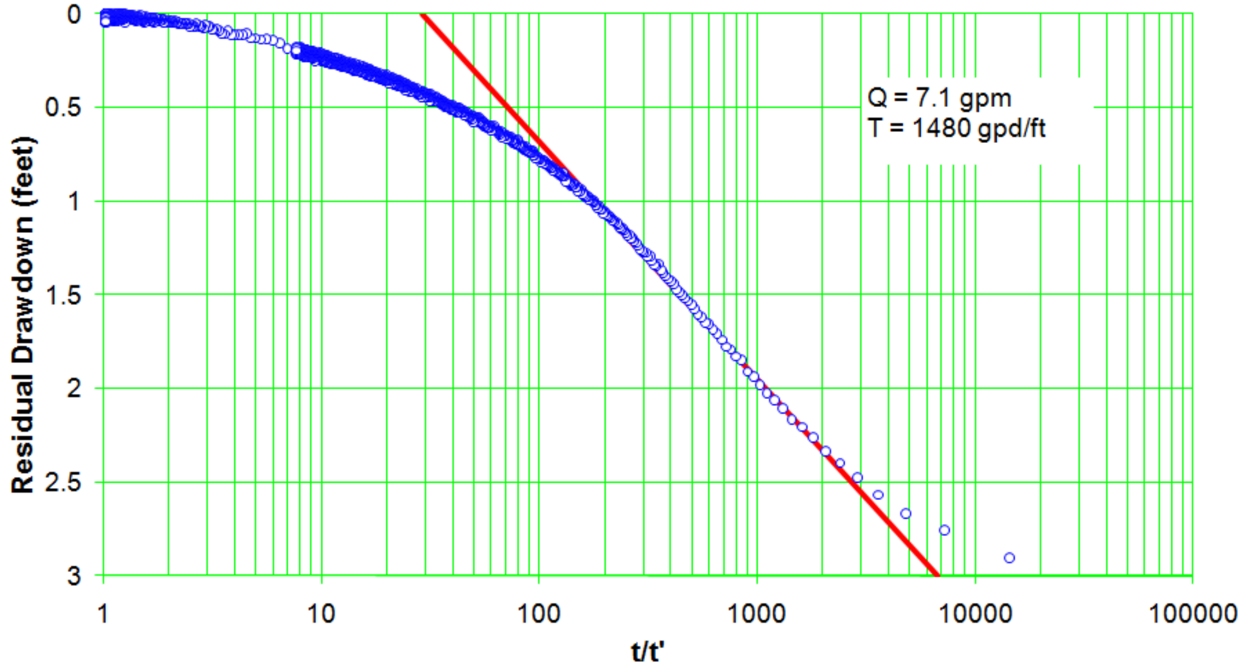


Figure E-8.2-3 Well R-30 trial 2 recovery

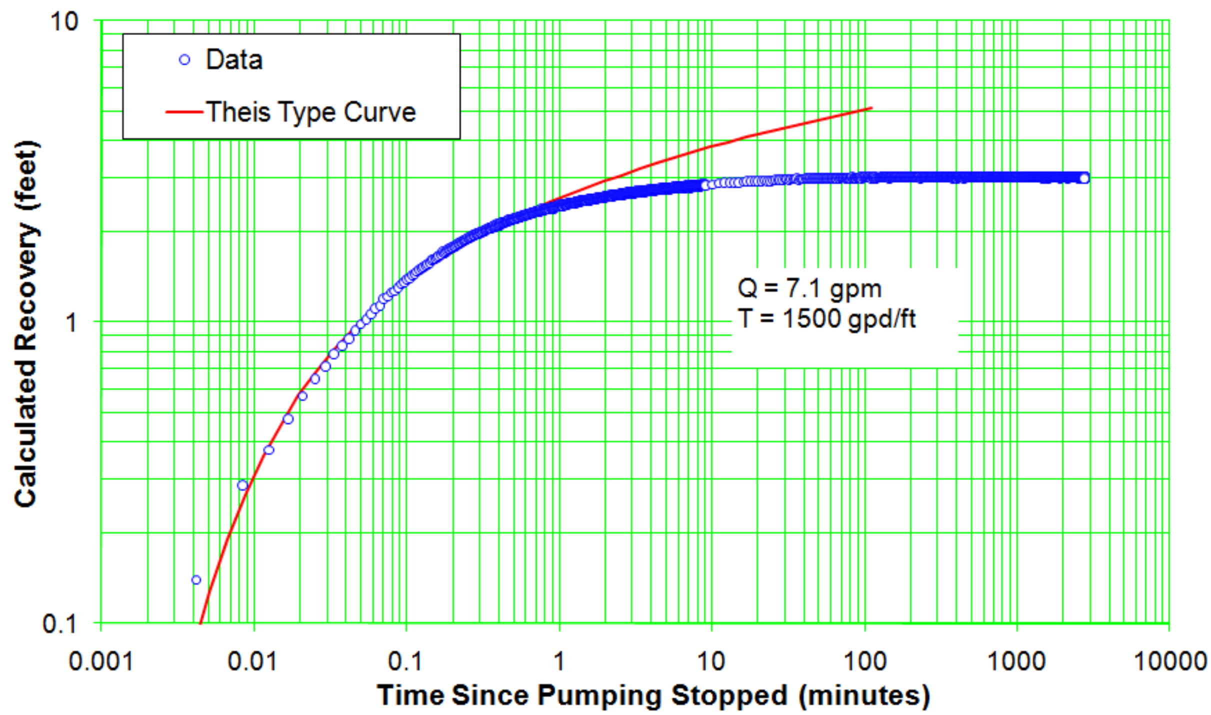


Figure E-8.2-4 Theis analysis of well R-30 trial 2 recovery

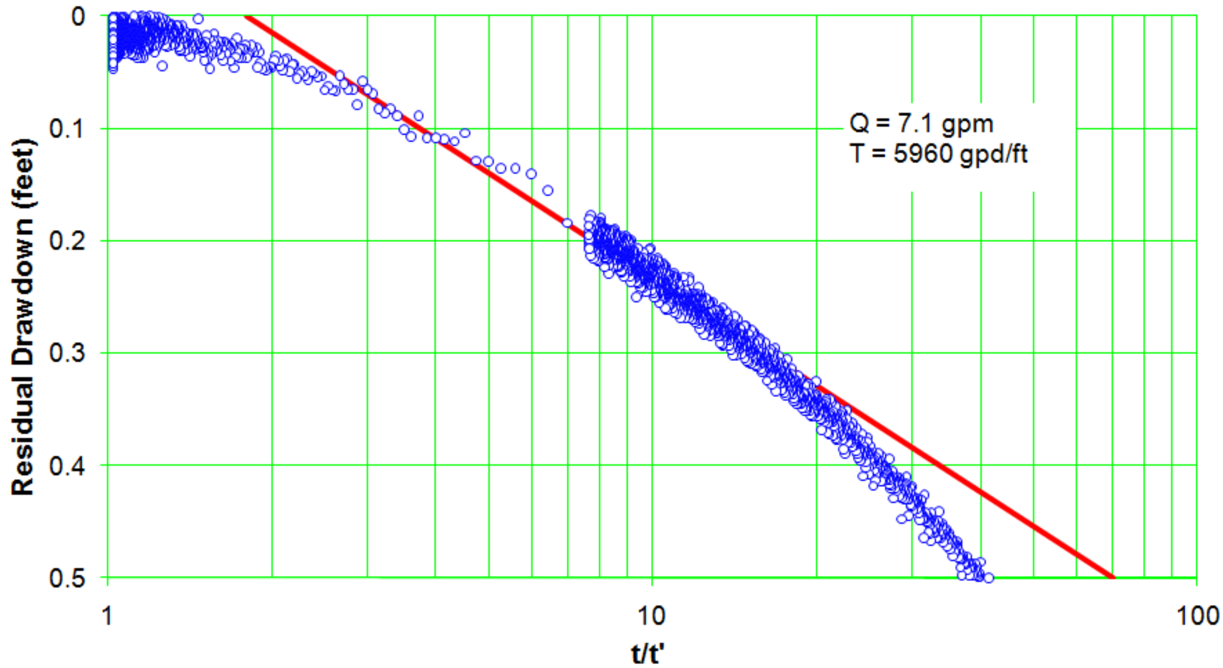


Figure E-8.2-5 Well R-30 trial 2 recovery—expanded scale

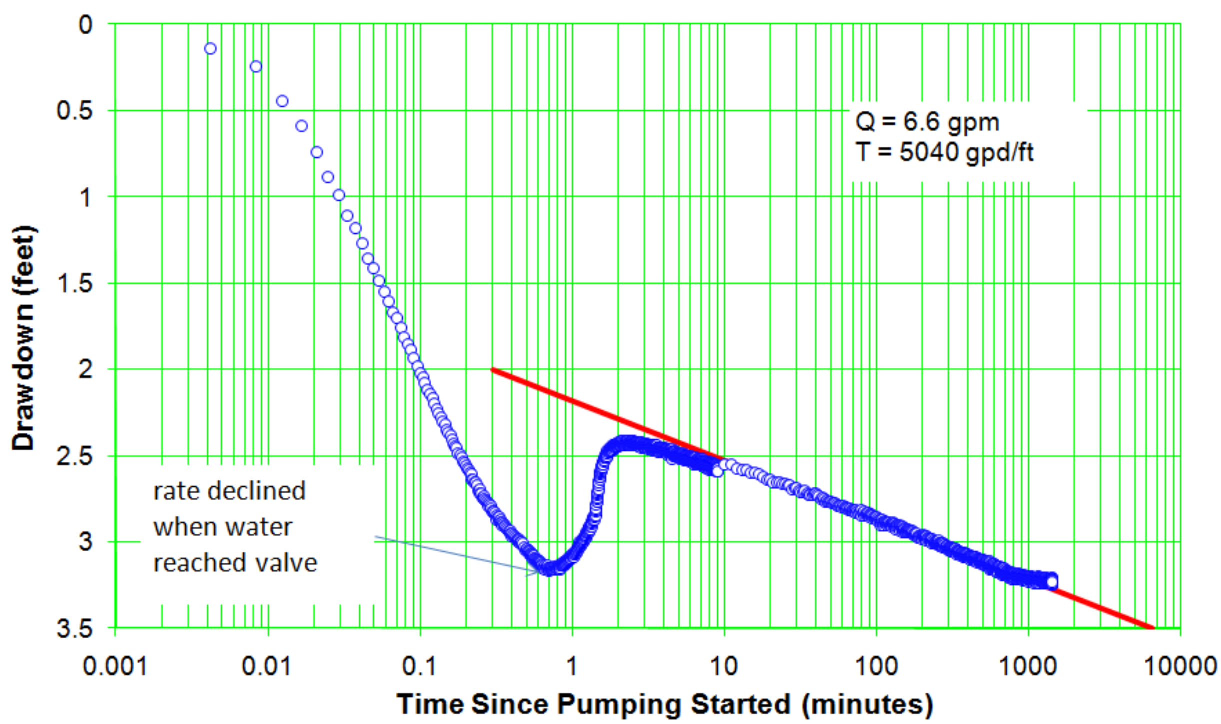


Figure E-8.3-1 Well R-30 drawdown

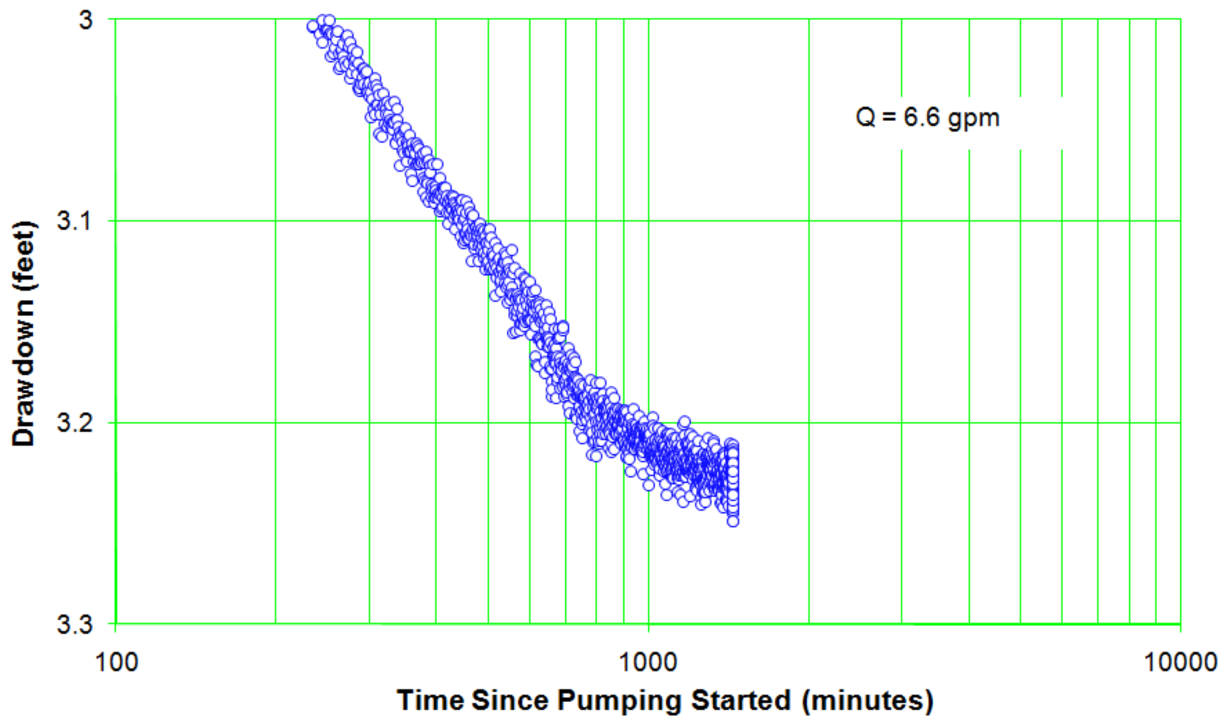


Figure E-8.3-2 Well R-30 drawdown—expanded scale

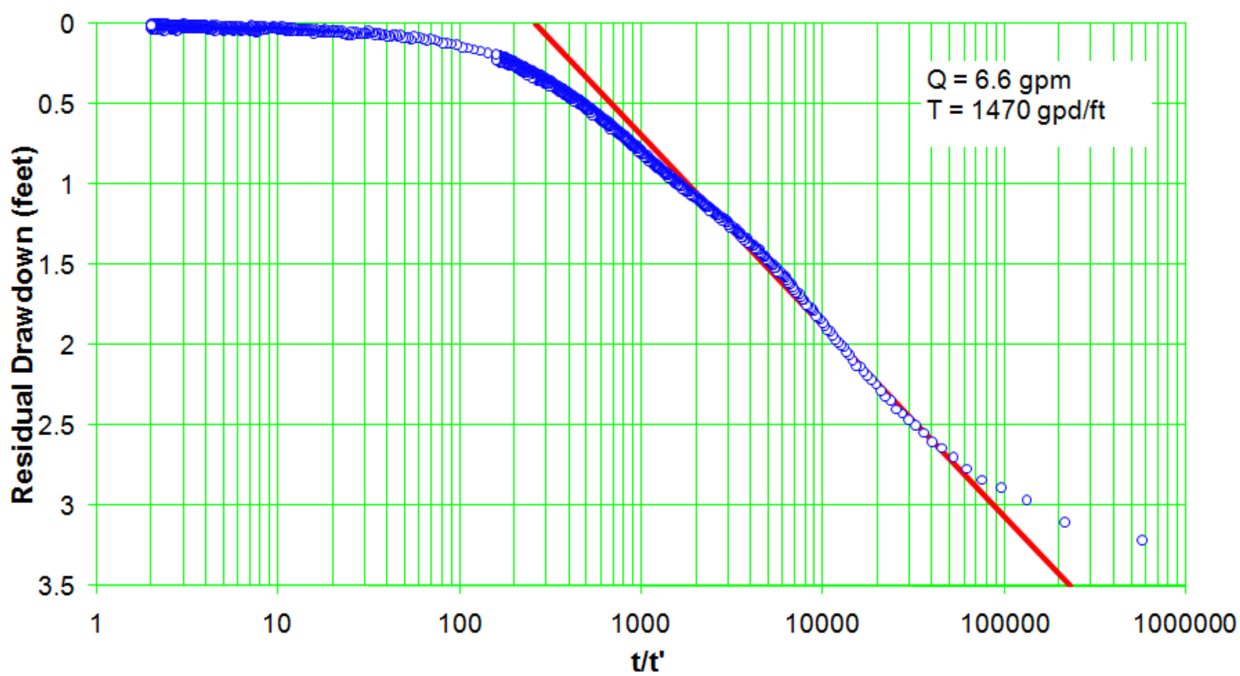


Figure E-8.3-3 Well R-30 recovery

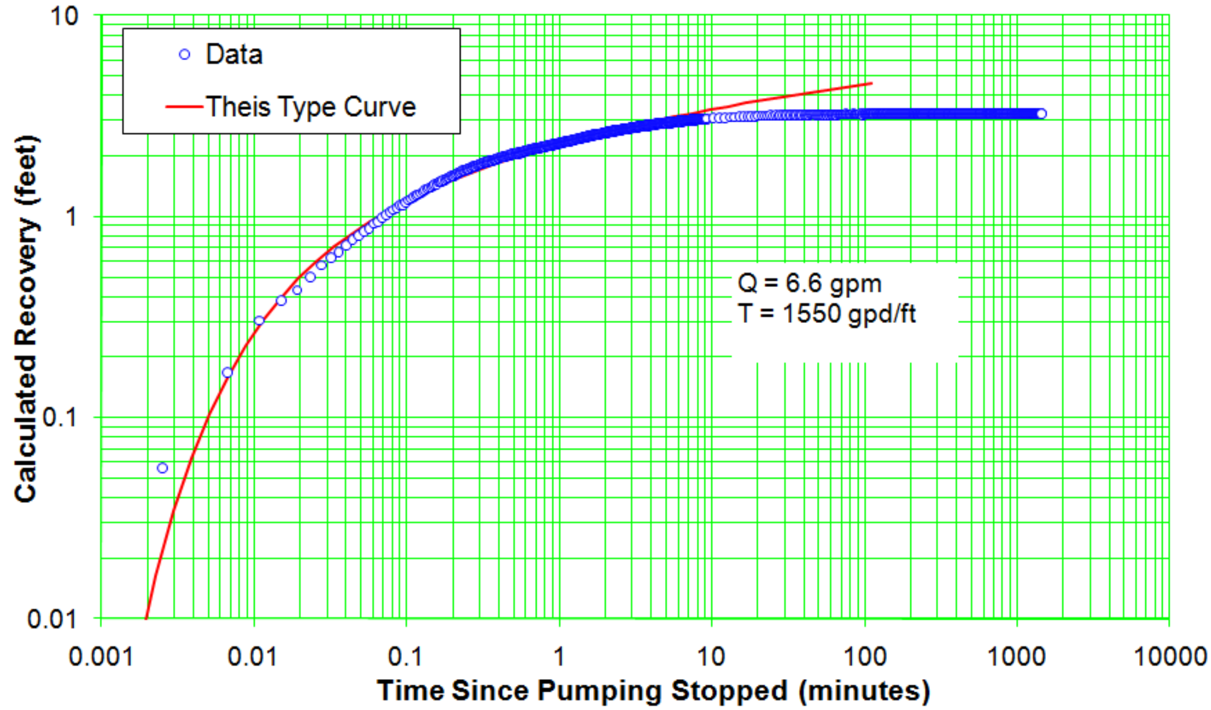


Figure E-8.3-4 Theis analysis of Well R-30 recovery

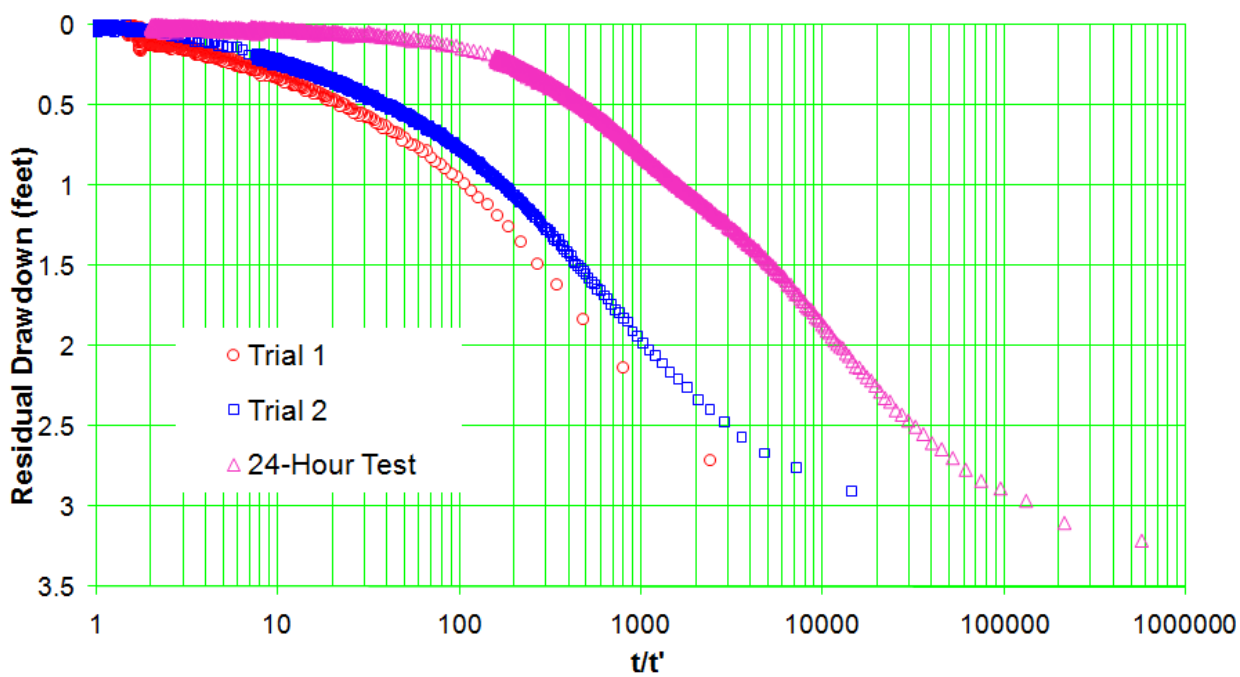
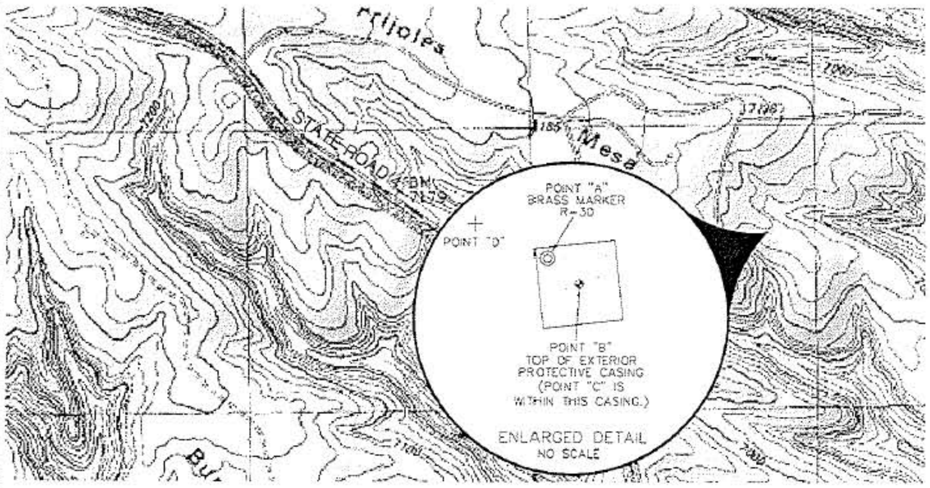


Figure E-8.4-1 Well R-30 residual drawdown—all tests

Appendix F

Survey Location Report

LANL MONITORING WELL LOCATION REPORT
DESIGNATED R-30
WITHIN TECHNICAL AREA 49
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS COUNTY, NEW MEXICO
JUNE, 2010



POINT	DESCRIPTION	EASTING (X)	NORTHING (Y)	ELEVATION
A	BRASS MARKER R-30	1626287.74	1753921.18	7073.84
B	TOP OF 16" PROTECTIVE CASING	1626291.65	1753917.96	7076.15
C	TOP OF 6" WELL	1626291.59	1753917.93	7075.86
D	GROUND	1626278.97	1753925.49	7073.14

Notes

1.) FIELD SURVEY COMPLETED ON JUNE 4, 2010.

2.) THIS AREA LIES WITHIN LOS ALAMOS NATIONAL LABORATORY PROPERTY IN TECHNICAL AREA 49, LOS ALAMOS COUNTY, NEW MEXICO.

3.) HORIZONTAL COORDINATES CALCULATED USING TOPCON HIPER+ RECEIVER AND ARE BASED UPON GPS LOCALIZATION DERIVED FROM LANL LAB WIDE CONTROL NETWORK MONUMENTS A0001, A0002, A0003, A0006, A0009, A0306, A1607, A1608, B0001, B0002, B0004, B3303, PAJ10, PAJ16, NMSR4 15 AND NMSR4 25. LANL LAB WIDE CONTROL NETWORK HORIZONTAL DATUM: NAD 1983.

4.) VERTICAL COORDINATES ARE BASED UPON GPS LOCALIZATION DERIVED FROM LANL LAB WIDE CONTROL NETWORK MONUMENTS A0003, A0006, A0306, A0602, A1607, A1608, B0001, B0004, B3303, BC1709, NMSR4-2, PAJ10, AND PAJ16. VERTICAL DATUM: NGVD 1929.

5.) HORIZONTAL COORDINATES ARE STATE PLANE GRID COORDINATES, NEW MEXICO CENTRAL ZONE, NAD 83.

AUTHORITY:
THIS MONITORING WELL LOCATION REPORT WAS PREPARED FROM A SURVEY DONE UNDER MY SUPERVISION ON THE 4TH DAY OF JUNE, 2010 AND FROM INSTRUCTION PROVIDED TO US BY NORTHWIND, INC.

LARRY W. MEDRANO, N.M.P.L.S. NO. 11993 — *DATE 7/9/2010*

LARRY W. MEDRANO NEW MEXICO 11993 REGISTERED PROFESSIONAL SURVEYOR

PRECISION SURVEYS, INC. 1460 TRINITY DRIVE, SUITE 3 LOS ALAMOS, N.M. 87544 **PHONE** (505) 661-4262 **FAX** (505) 661-4263